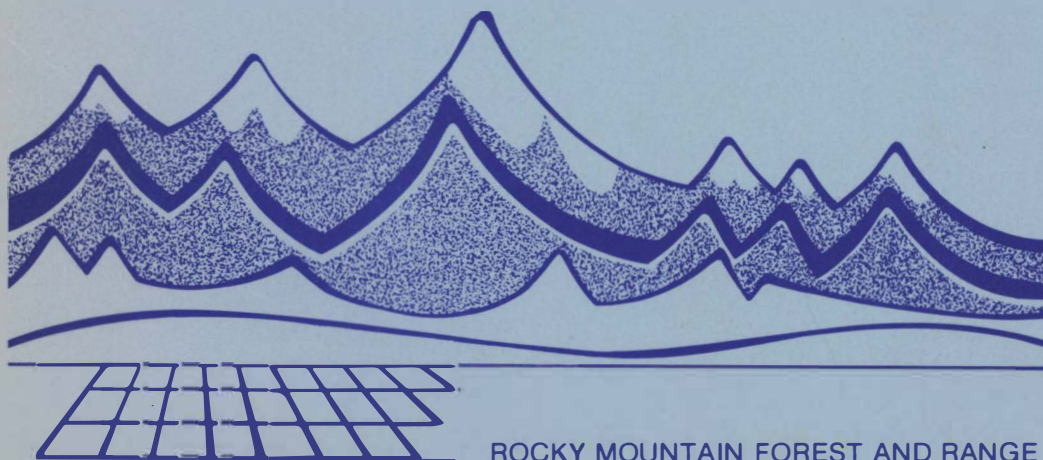


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Leaf,
C. A.

SUMMARY REPORT

HYDROLOGY OF THE PARK RANGE,
NEAR STEAMBOAT SPRINGS, COLORADO



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Atmospheric Water Resources Program

SUMMARY REPORT

HYDROLOGY OF THE PARK RANGE,
NEAR STEAMBOAT SPRINGS, COLORADO

by

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Rocky Mountain Forest and Range Experiment Station
Forest Service - U.S. Department of Agriculture

Division of Atmospheric Water Resources Management
Bureau of Reclamation - U.S. Department of the Interior

INTRODUCTION

An important part of the Atmospheric Water Resources Program is to evaluate the effects of cloud seeding on snowpack accumulation and resultant runoff. This long-range weather modification investigation is a cooperative effort administered by the Bureau of Reclamation. The Rocky Mountain Forest and Range Experiment Station has been one of several participants in the program.

As a cooperator in this program, the Experiment Station agreed to develop information to evaluate the effect of watershed management practices on the hydrologic behavior of timber-snow zone watersheds in the Central Rocky Mountain Region.

The weather modification study areas are an aggregate of many small watershed units differing in aspect, soils, elevation, and plant cover. For best use of weather modification techniques, and for efficient water management, it is necessary to understand the factors controlling small watershed hydrology. For example, increased snowpack may have greater value on one portion of an area than in another. It melts at different times and contributes to different parts of the streamflow hydrograph. Also, consumptive use and watershed recharge requirements can vary widely from place to place. For these reasons, the Station made a thorough study of the hydrology of small watersheds in Bureau of Reclamation target areas.

In the Park Range near Steamboat Springs, Colorado, three watersheds with a size range of 1.3 to 3.4 square miles were selected for study; during the summer of 1966, prefabricated lightweight streamflow gaging stations were constructed. Besides streamflow measurements, the seasonal snowpack on all three experimental watersheds was intensively sampled. Precipitation measurements were also made through the snowmelt season and during the summer and fall months. An investigation of the forest cover and geologic conditions in the Park Range watersheds was undertaken. These efforts have produced a comprehensive hydrologic data base, and have also provided a realistic basis for planning the more intensive work needed to characterize the study area.

Repeated aerial surveys of snow cover during the melting period have revealed a characteristic melt pattern for the Park Range, which depends on elevation, aspect, and forest cover. Establishment of this pattern made it possible to estimate the time of streamflow peak, residual flow volume, and provided information for determining where an increase in snow is of most benefit to streamflow.

Studies of snow-cover depletion in the Park Range have also provided information on dates of final melt on Bureau of Reclamation target areas. We have derived relationships between duration of snow cover and amount of snowpack accumulation. These correlations will be useful in determining the ecologic effects of weather modification.

Finally, a versatile model was developed to simulate:

(1) snow accumulation, (2) energy balance, (3) snowpack condition, snowmelt in time and space, and resultant streamflow from a variety of environmental conditions. These conditions include any combination of: (1) aspect, (2) slope, (3) elevation, and (4) forest cover composition and density. Our use of this model in the Central Rocky Mountain Region has enabled us to determine the probable effects of additions to the winter snowpack through weather modification.

This summary report contains detailed analyses and discussion of the research activities described above.

PARK RANGE TARGET AREA

INVENTORY OF HISTORICAL STREAMFLOW RECORDS

As a first step, we made detailed analyses of available historical runoff records from the Park Range project area near Steamboat Springs, Colorado. The analyses of early streamflow records are based on data that were collected by the U.S. Geological Survey and the Colorado State engineer in and near the target area. The locations of the sites are shown in figure 1.

An inventory of the years of streamflow records used for analysis are listed in table 1.

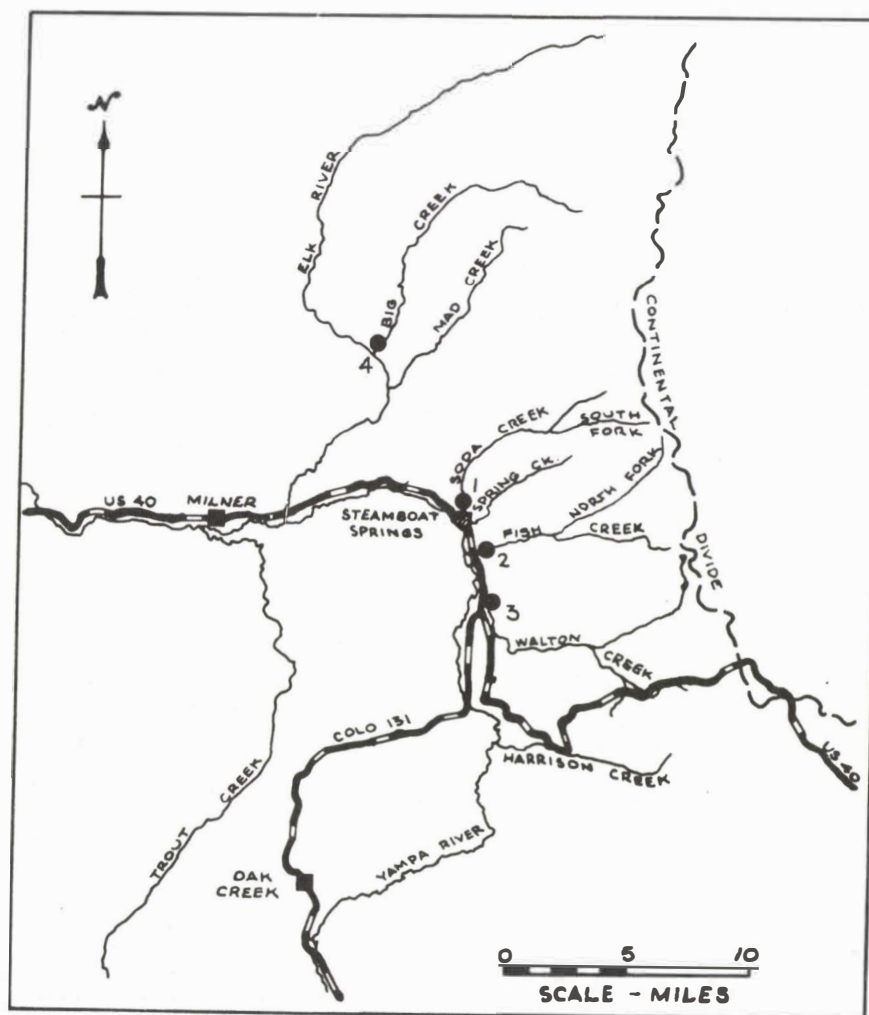


Figure 1.--Sites in target and adjoining areas in Park Range where historic streamflow data are analyzed. The black circles show the locations of the gaging stations.

Table 1.--Inventory of early streamflow records in the
Park Range^{1/}

Number on fig. 1	Stream and location	Drainage area (sq. mi.)	Years of defined discharge data										
			1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921
1	Soda Creek at Steamboat Springs, Colo.	47	X	X	X	X	X	X	X	X			
2	Fish Creek at Steamboat Springs, Colo.	26									X	X	
3	Walton Creek near Steamboat Springs, Colo.	38											X X
4	Big Creek near Steamboat Springs, Colo.	41								X	X		

^{1/} Data taken from Water Supply Paper 1313, "Compilation of Records of Surface Waters of the United States through September, 1950, Part 9, Colorado River Basin."

Annual Water Yields

Annual water yields are summarized in table 2. According to early records, snowmelt runoff from the Rabbit Ears Peak area on the Continental Divide is exceptionally high. Annual specific yields measured in c.f.s. per square mile (the mean discharge divided by drainage area) from Fish Creek and Walton Creek are summarized in table 3.

Table 3.--Annual specific yields from Fish Creek and
Walton Creek

Year	Fish Creek	Walton Creek
	<u>specific yield--c.f.s./mi²</u>	
1919	2.59	
1920	4.81	
1921		3.76
1922		2.30
Average	3.70	3.03

If the record is correct, specific yields from the target area may well be the highest in the state. Yevdjevich (1964) studied about 300 small watersheds in the Colorado River Basin Continental Divide area in Colorado, and found that specific yields did not exceed 2.4 c.f.s./sq. mi. This compares with a maximum 4.8 c.f.s./mi² from Fish Creek and 3.8 c.f.s./mi² from Walton Creek. Average runoff at Steamboat Springs was 11 percent above the 49-year mean in 1919 and 1920 and 22 percent above the mean in 1921 and 1922.

Table 2.--Yearly runoff from watersheds in watersheds
in Atmospheric Water Resources Project Area

Soda Creek at Steamboat Springs, Colorado
(approximately 47 sq. mi.)

Water year	Runoff, in acre-feet	Runoff, in inches
1911	37,670	15.1
1913	20,130	8.0
1914	32,770	13.1
1915	25,100	10.0
1916	34,800	13.9
1917	52,380	21.0
1918	45,390	18.2
1919	28,920	11.6

Fish Creek at Steamboat Springs, Colorado
(26 sq. mi.)

Year	Period of record	Runoff, in acre-feet	Runoff, in inches
1919	April 21 - Oct. 31	43,319	26.0
1920	April 5 - Oct. 31	87,458	52.6

Walton Creek near Steamboat Springs, Colorado
(38 sq. mi.)

Year	Period of record	Runoff, in acre-feet	Runoff, in inches
1921	May 23 - Dec. 31	88,825	36.6
1922	March 26 - Sept. 30	54,845	22.6

Big Creek near Steamboat Springs, Colorado
(41 sq. mi.)

Year	Period of record	Runoff, in acre-feet	Runoff, in inches
1918	May 10 - Nov. 30	34,377	15.8
1919	April 1 - Nov. 10	30,221	13.8

The Snowmelt Hydrograph

Typically, most of the annual flow from the Upper Colorado River Basin is delivered from April through June. In the Fraser River drainage, streamflow begins to increase from a winter minimum in April and reaches peak levels in June. Runoff during May and June accounts for about 65 percent of the May to September flow. This compares with about 85 percent for streams in the Park Range. The accelerated runoff produces exceptionally high peaks, as noted in the accompanying hydrographs of the Fraser River, which is typical of streams which drain much of the subalpine zone, and streams in the Park Range (figs. 2 to 7). The marked seasonal concentration of flows is also illustrated in figure 8, which shows the monthly distribution of May to September water yield.

The forested watersheds of the Fraser River have a greater capacity for the penetration and storage of snowmelt runoff, which provides for a sustained late-season flow. Streamflow from the Park Range recedes rapidly from a sharply concentrated peak with very little late-season flow from snowmelt. As discussed later in this report, any increase in runoff as the result of weather modification would be delivered early and produce a somewhat greater concentration of flows.

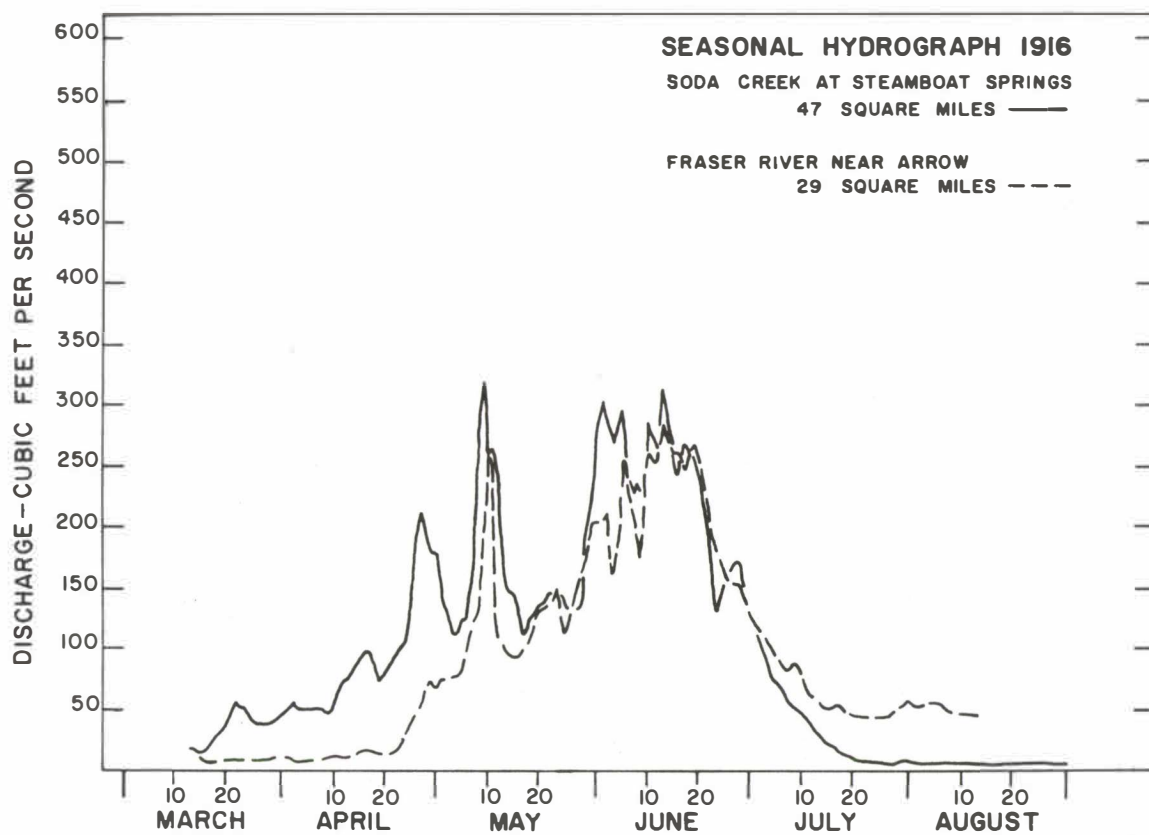


Figure 2.--Comparison of seasonal hydrographs from Soda Creek and Fraser River, 1916.

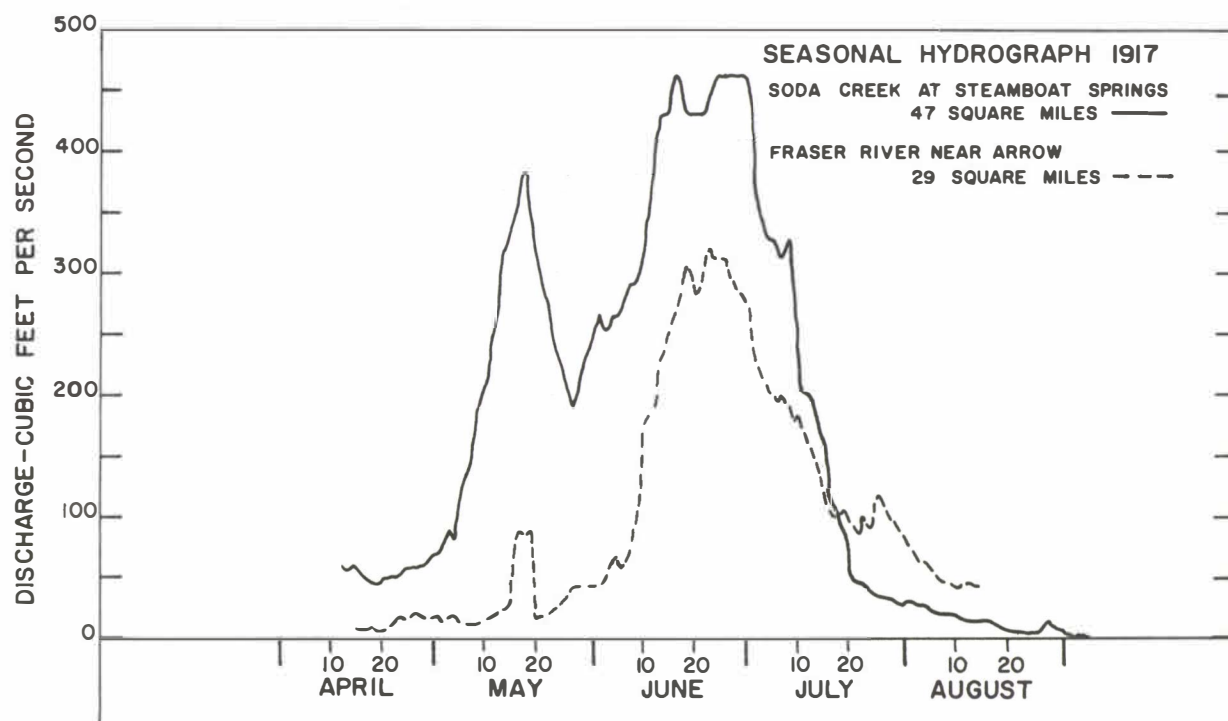


Figure 3.--Comparison of seasonal hydrographs from Soda Creek and Fraser River, 1917.

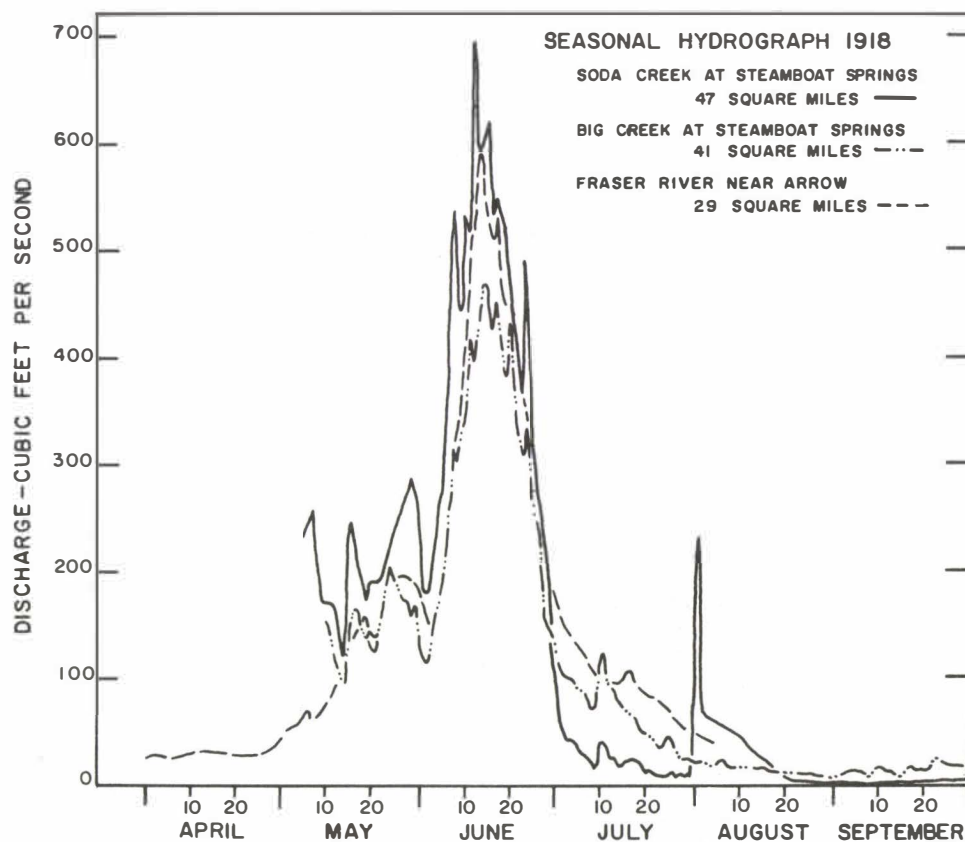


Figure 4.--Comparison of seasonal hydrographs from Soda Creek, Big Creek, and Fraser River, 1918.

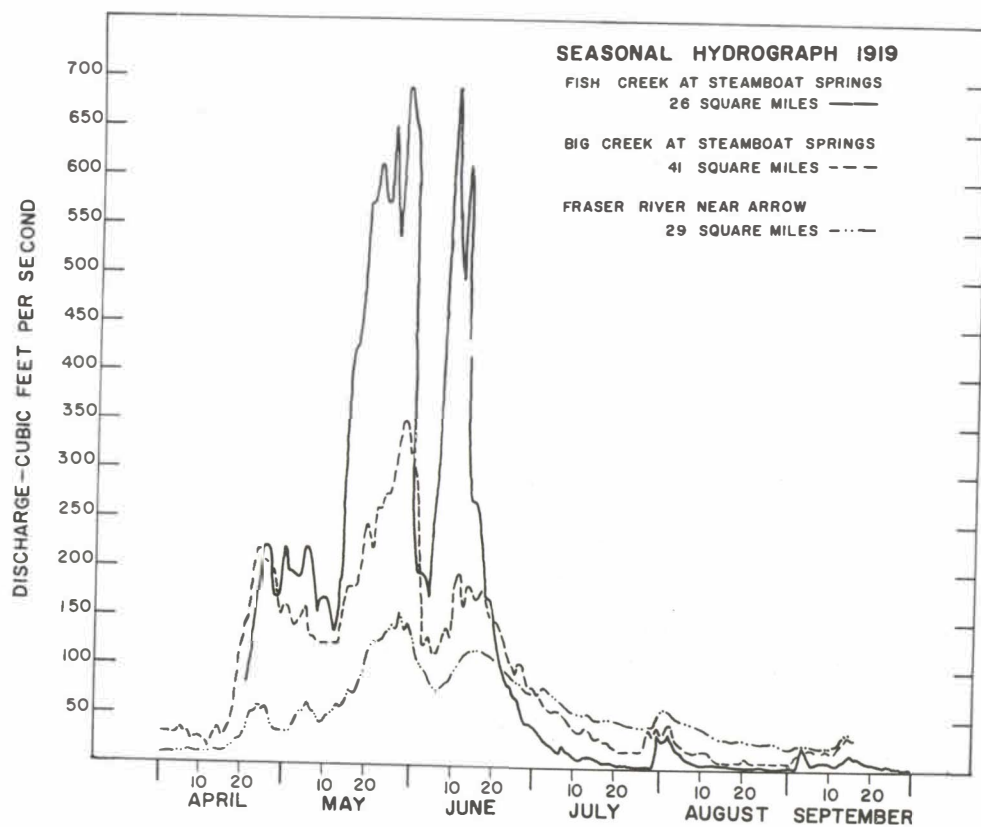


Figure 5.--Comparison of seasonal hydrographs from Fish Creek, Big Creek, and Fraser River, 1919.

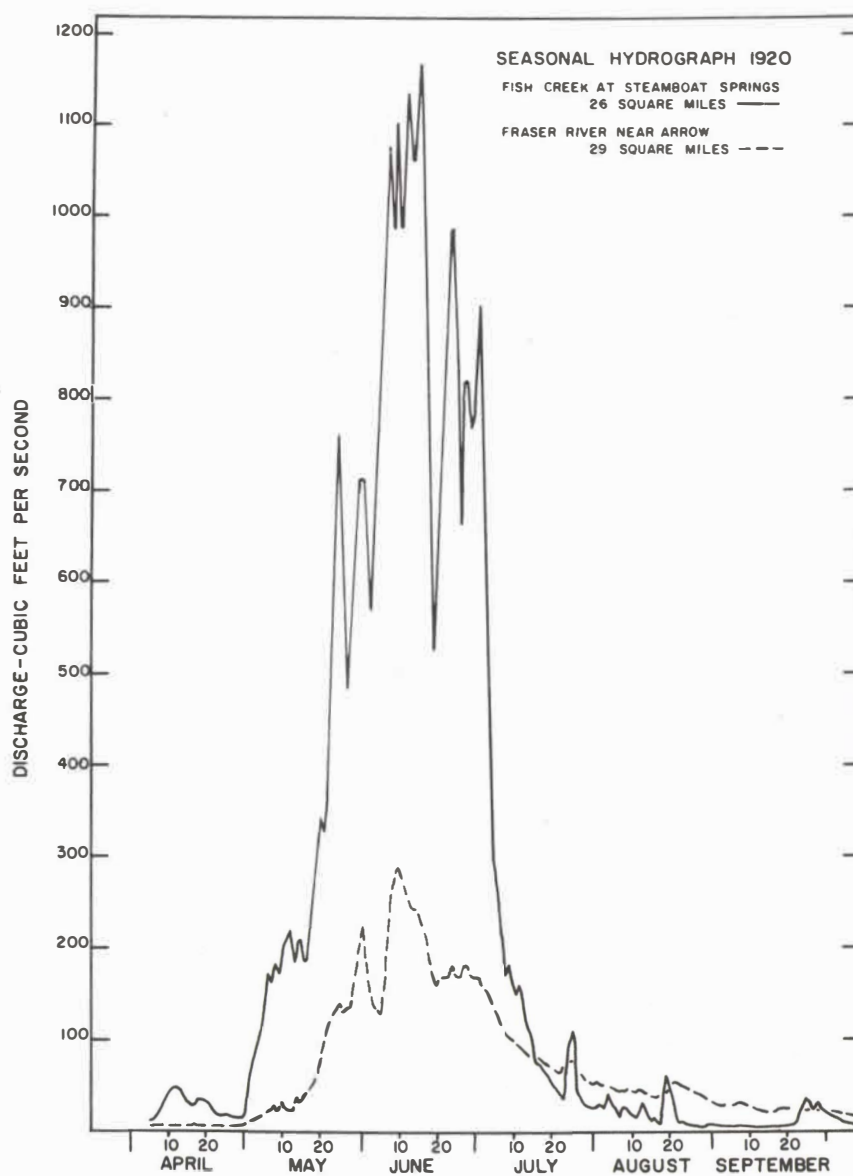


Figure 6.--Seasonal hydrograph from Fish Creek and Fraser River, 1920.

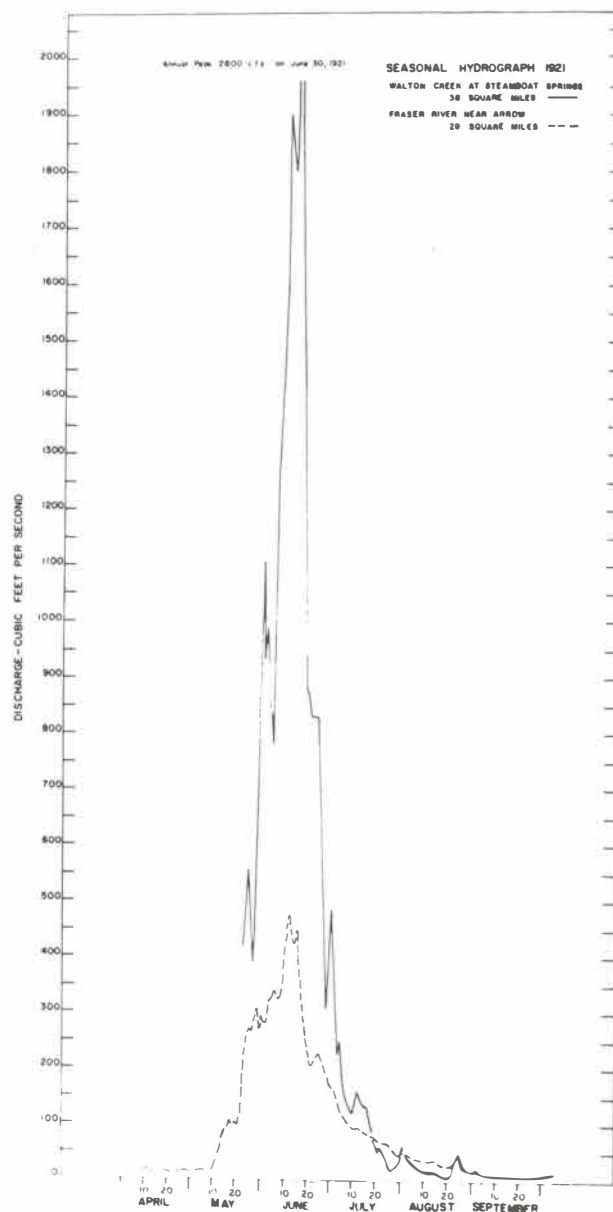


Figure 7.--Comparison of seasonal hydrographs from Walton Creek
and Fraser River, 1921.

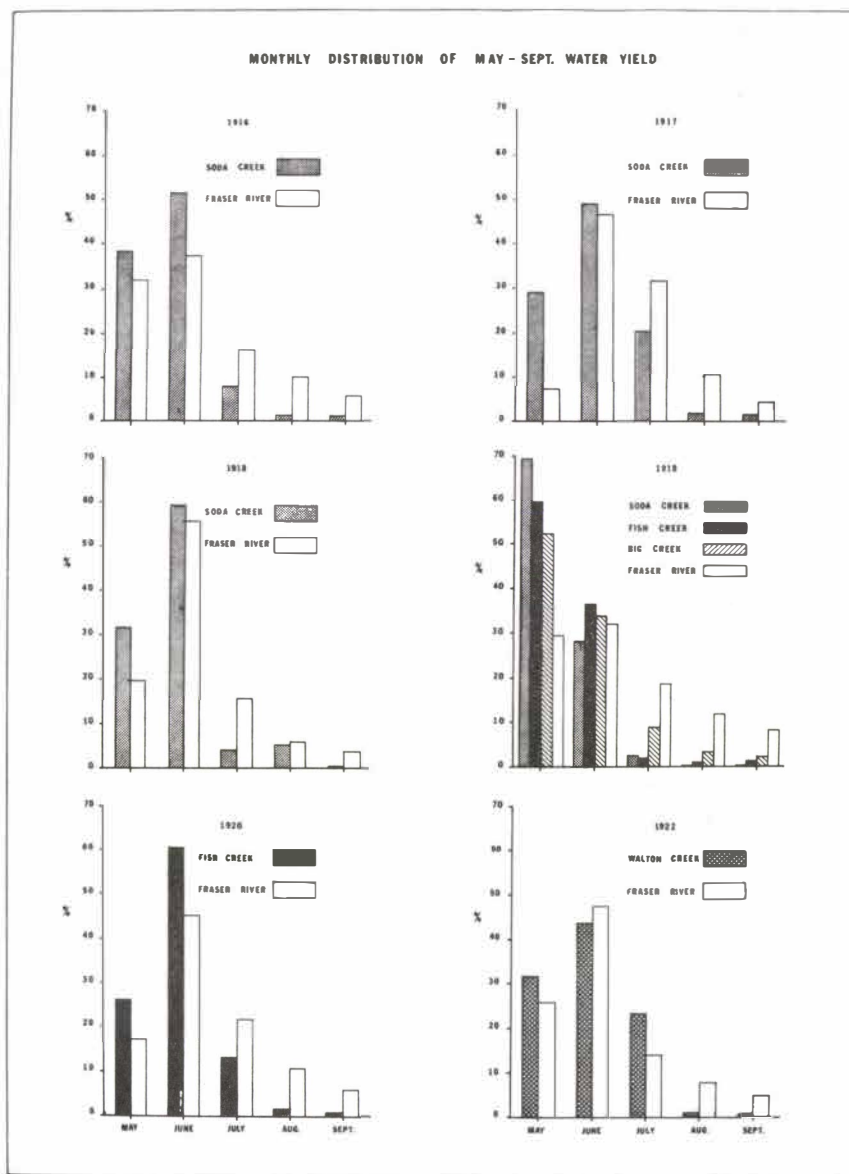


Figure 8.--Monthly distribution of May-September water yields
from the Fraser River and Park Range watersheds.

THE EXPERIMENTAL WATERSHEDS

The watersheds selected for study in the Park Range test area are tributaries of Soda Creek, Fish Creek, and Walton Creek. Their locations are shown in figure 9. Oblique aerial views of the watersheds are shown in figures 10 and 11.

During the summer of 1966, Cipolletti weirs were installed on each of the three watersheds. All of the gages are similar; only minor modifications in the general design were necessary at each site. Because accessibility was a problem at all of the gaging sites, it was decided to use red cedar timber for the cutoff walls. The walls were prefabricated and hauled to the job site in panels. Design features of the streamgaging stations are summarized in Appendix A.

Soda Creek

Soda Creek watershed (fig. 12) ranges in elevation from about 8,300 feet above mean sea level at the streamgage to 10,724 feet on the Continental Divide. The watershed is oriented approximately east to west. The slopes are generally north and south exposures. The area of Soda Creek is 2,174 acres (3.4 square miles).

Fish Creek

Fish Creek (fig. 14) ranges in elevation from about 9,800 feet at the stream gage to a maximum of 10,724 feet. The area of Fish Creek is 1,435 acres (2.2 square miles).

Walton Creek

Walton Creek (fig. 16) ranges in elevation from about 9,100 feet at the streamgage to a maximum of 9,728 feet along the north boundary of the watershed. The stream flows generally northeast. Much of Walton Creek faces south.

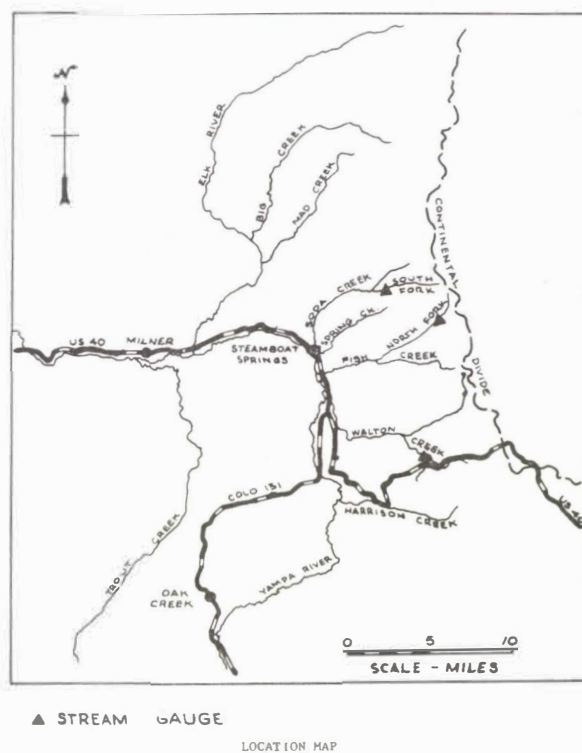


Figure 9.--Location map for Park Range experimental watersheds
established in 1966.

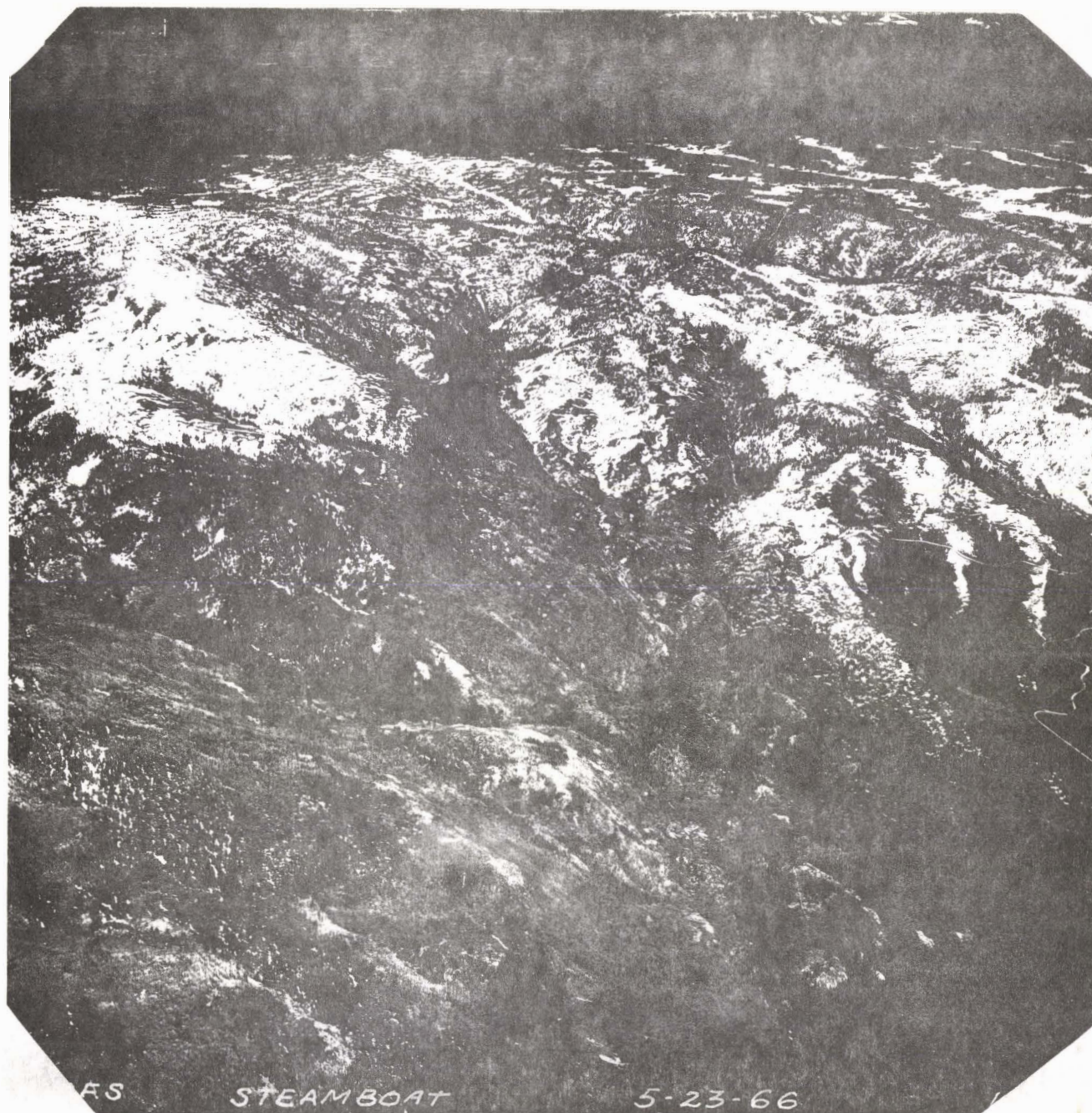


Figure 10.--South Fork of Soda Creek. The main stem is shown in the left foreground. The streamgage is located about three-fourths of a mile above the confluence on the tributary in the center of the photograph. The North Fork of Fish Creek lies to the left of the powerline right-of-way at the top of the photograph. The streamgage is approximately located where the powerline crosses Fish Creek.



Figure 11.--Walton Creek. The streamgage is located to the left of the highway in the upper righthand corner of the photograph. The main stem is shown in the upper left. Walton Peak is located in the lower righthand corner.

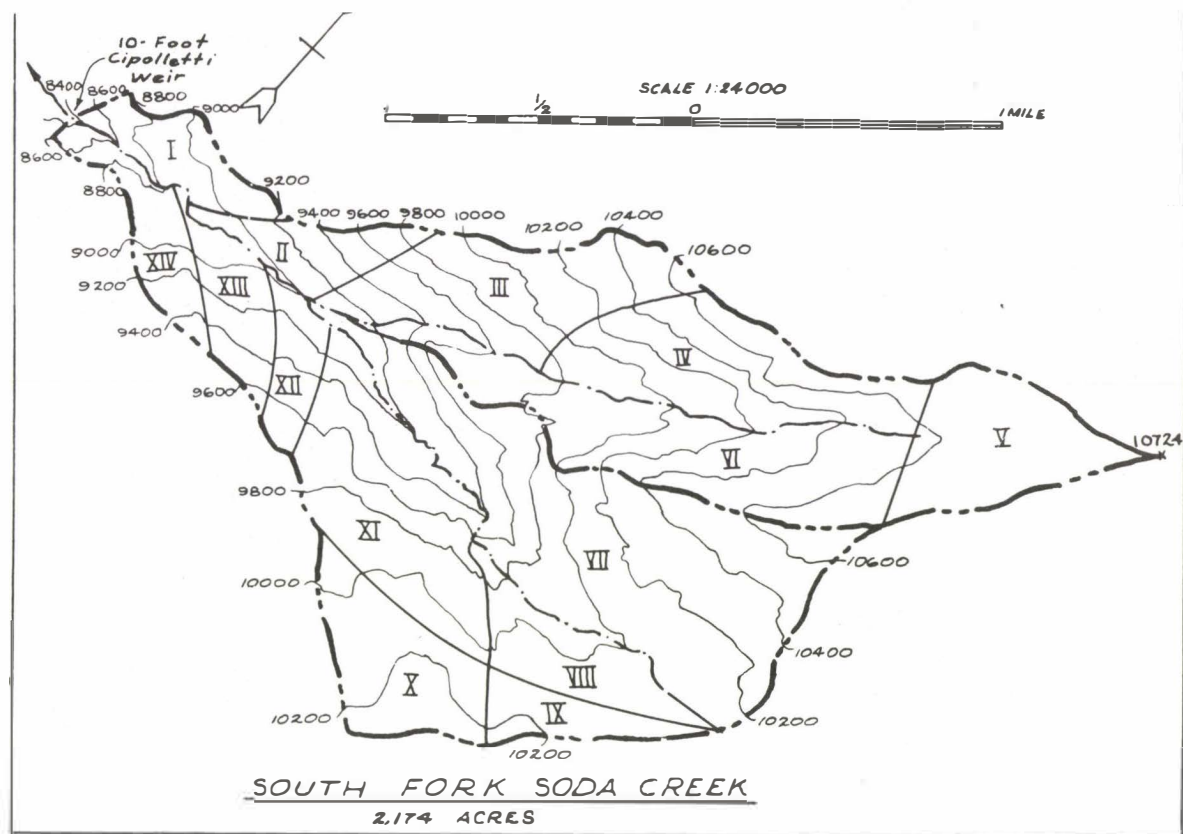


Figure 12.--South Fork of Soda Creek - topographic base map.

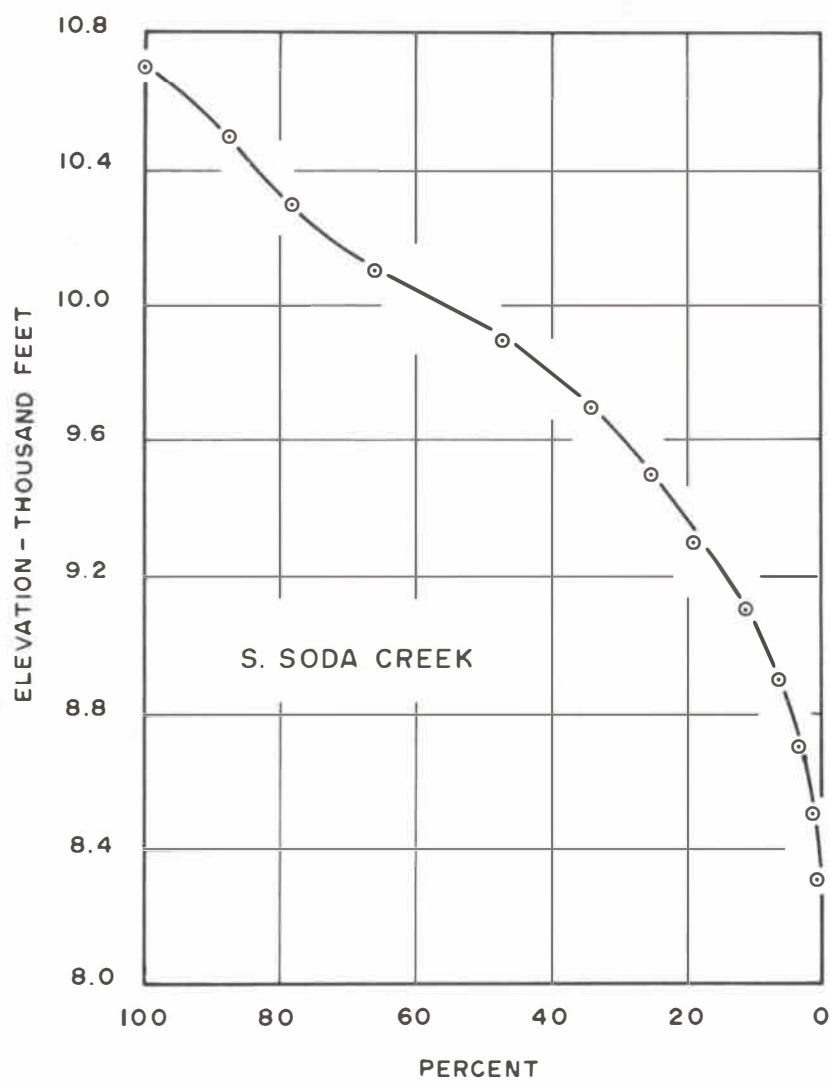


Figure 13.--Area-elevation curve - south fork of Soda Creek.

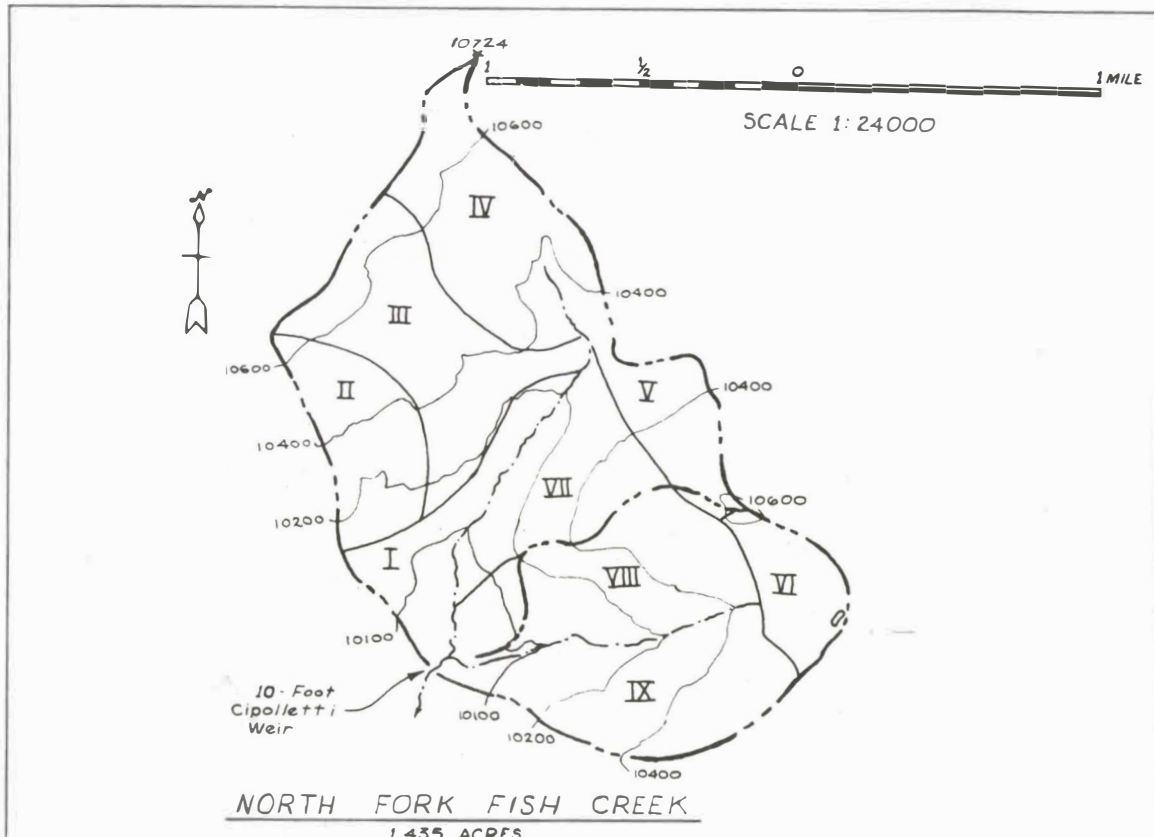


Figure 14.--North Fork of Fish Creek - topographic base map.

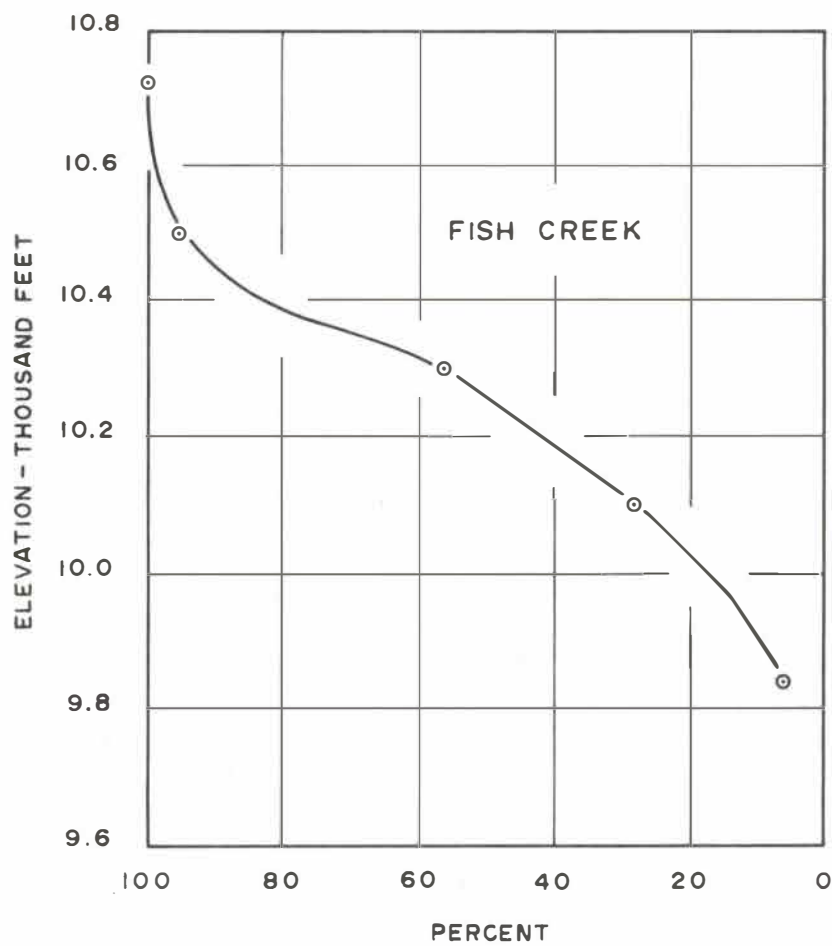


Figure 15.--Area-elevation curve - North Fork of Fish Creek.

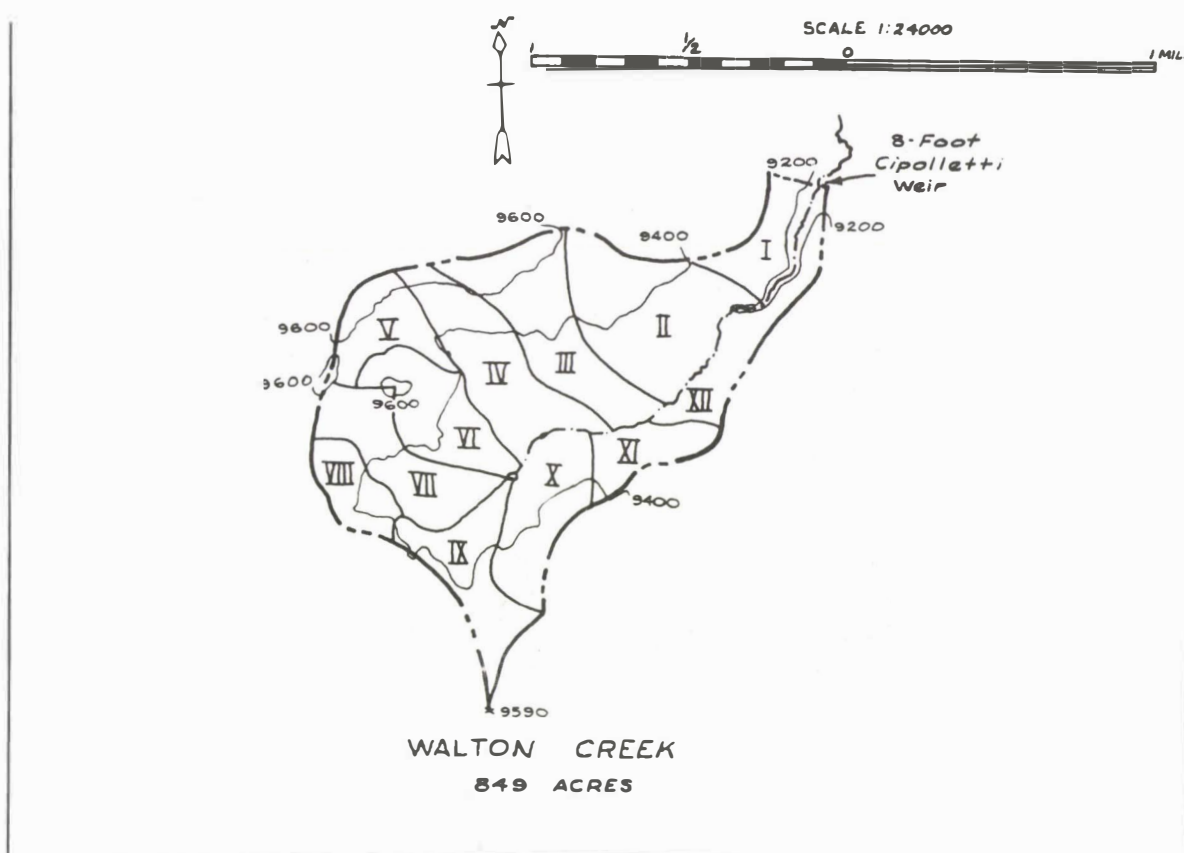


Figure 16.--Walton Creek - topographic base map.

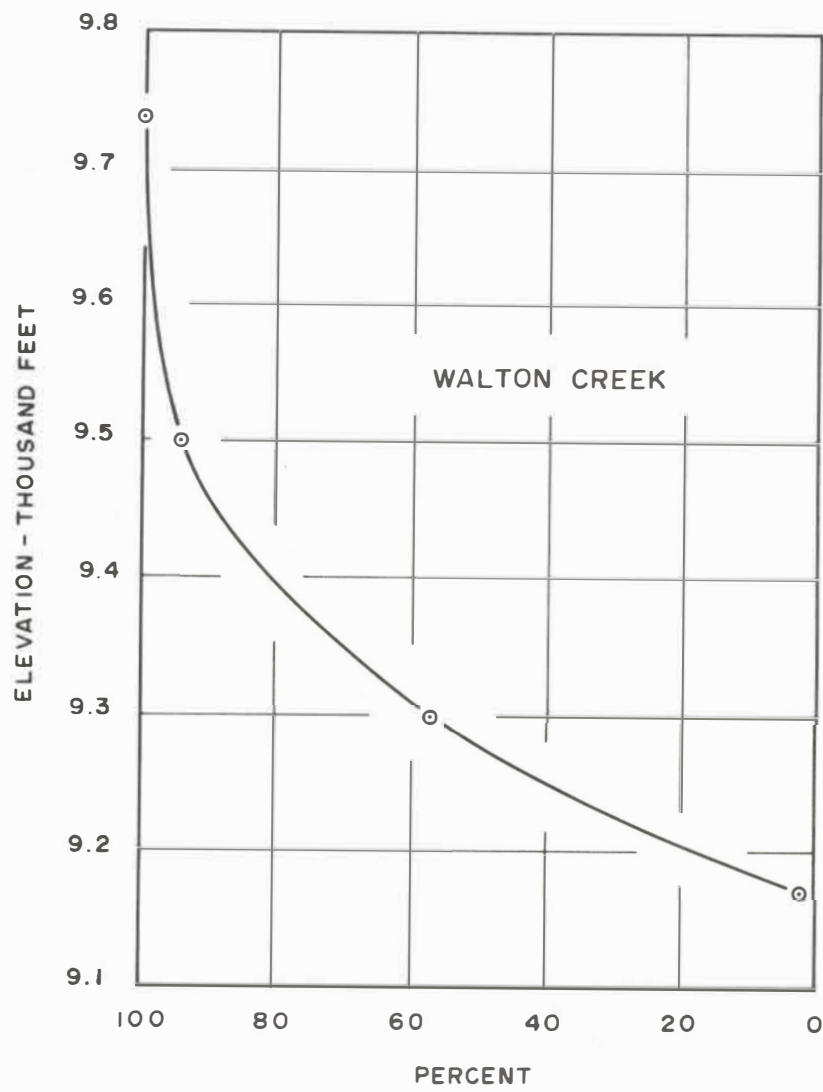


Figure 17.--Area-elevation curve - Walton Creek.



Figure 18.--Walton Creek gaging station at peak flow.

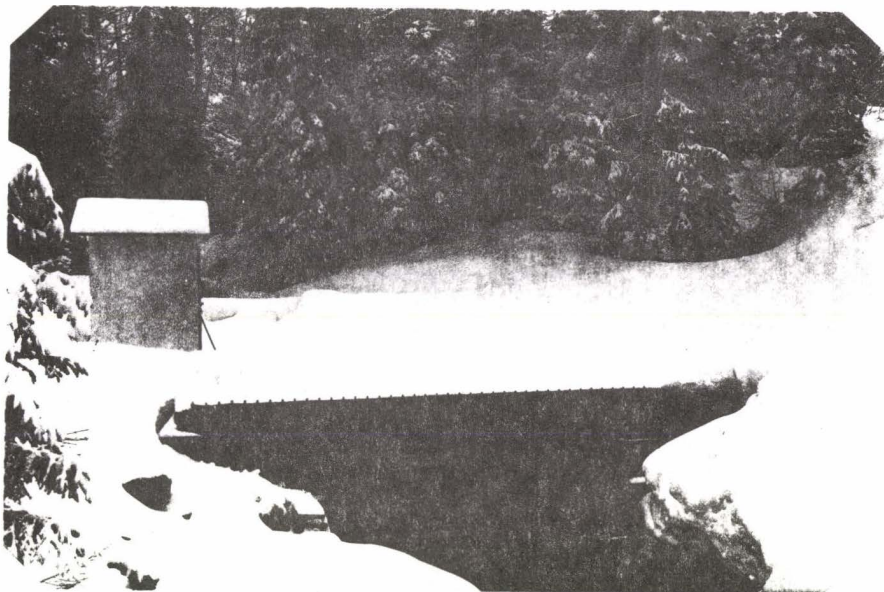


Figure 19.--Soda Creek gaging station at the beginning of
snowmelt runoff.



Figure 20.--Peak seasonal snowpack accumulation on Fish Creek.

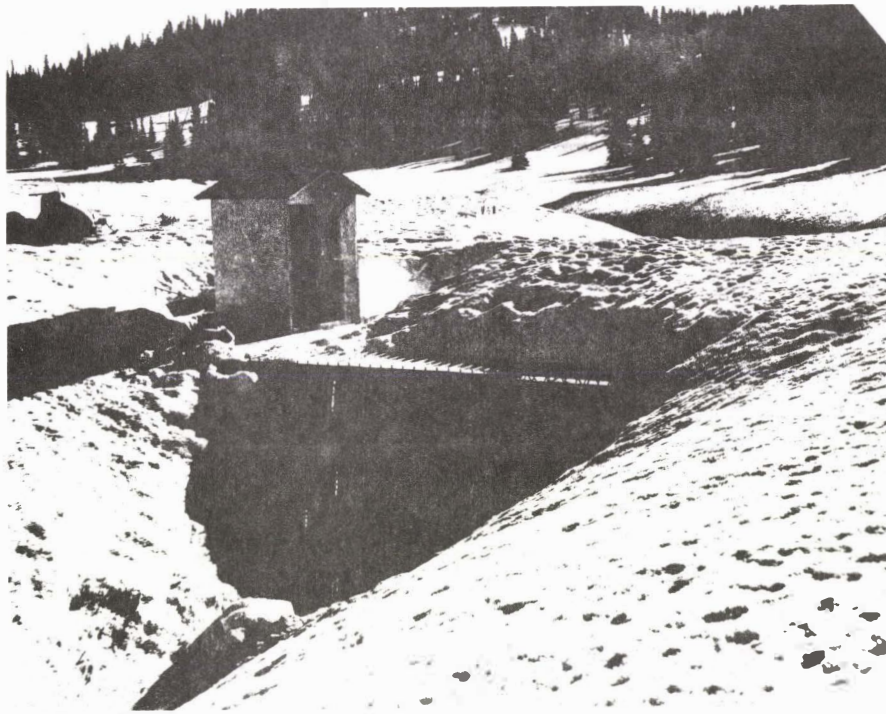


Figure 21.--Fish Creek gaging station near peak flow.

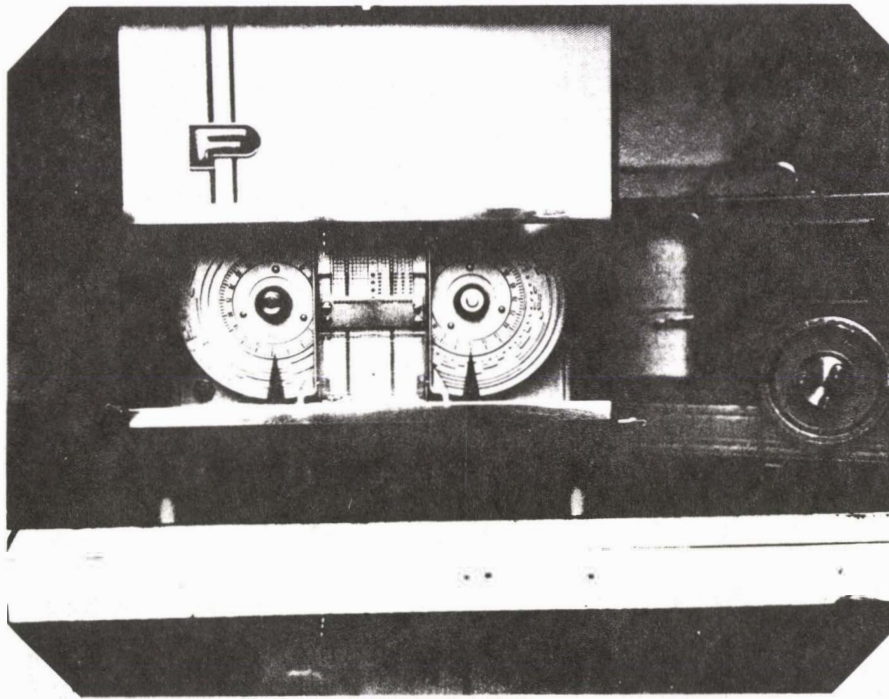


Figure 22.--Fisher-Porter punch tape stage recorder with auxiliary
FW-1 autographic recorder in the background.

VEGETATION

History.--The forests of the Park Range have suffered three catastrophies during the past 125 years: (1) a spruce beetle outbreak about 1850, (2) a devastating fire set by the Ute Indians in 1879, and (3) the spruce beetle outbreaks of 1941 and 1952. All three experimental watersheds have been visibly scarred by these events (Wilford 1967).

Walton Creek

The higher slopes of Walton Creek support stands of spruce-fir, lodgepole pine, and quaking aspen. Narrow strips of willows border the main stream channel and its tributaries. The numerous beaver ponds and springs on Walton Creek are also surrounded by heavy willow growth.

The east and southeast exposures of Walton Creek were completely destroyed by spruce beetles in the mid-1800's and the subsequent Ute fire in 1879. According to Wilford (1967), these slopes were once forested with a dense stand of spruce-fir and lodgepole pine.

Fish Creek

On Fish Creek, spruce-fir is the only tree type represented. Approximately 60 percent of the watershed is forested. The remaining 40 percent is made up of rock outcroppings, talus, willow growth along the stream channels, and wet meadows of upland-herbs.

Significant features near the Continental Divide are large alpine parks with interspersed narrow strips of spruce and fir trees. These strips are generally oriented north-south, and have a notable effect on snow accumulation (fig. 23). Below 10,300 feet, particularly on north-and northwest-facing slopes, the forest grows in a more typical block pattern.

Fish Creek was also affected by the beetle epidemics and the Ute fire; however, the fire did not damage much timber above 10,000 feet. The strips of spruce-fir near the Continental Divide were not affected by the fire, but spruce beetles have killed some trees (Wilford 1967).

The 1879 fire devastated the forest cover on the rocky southwest slope from the main stream course up to the high point of the ridge to about where the Buffalo Pass road crosses the Divide between Fish and Soda Creeks. This burned-over slope now supports scattered spruce trees.

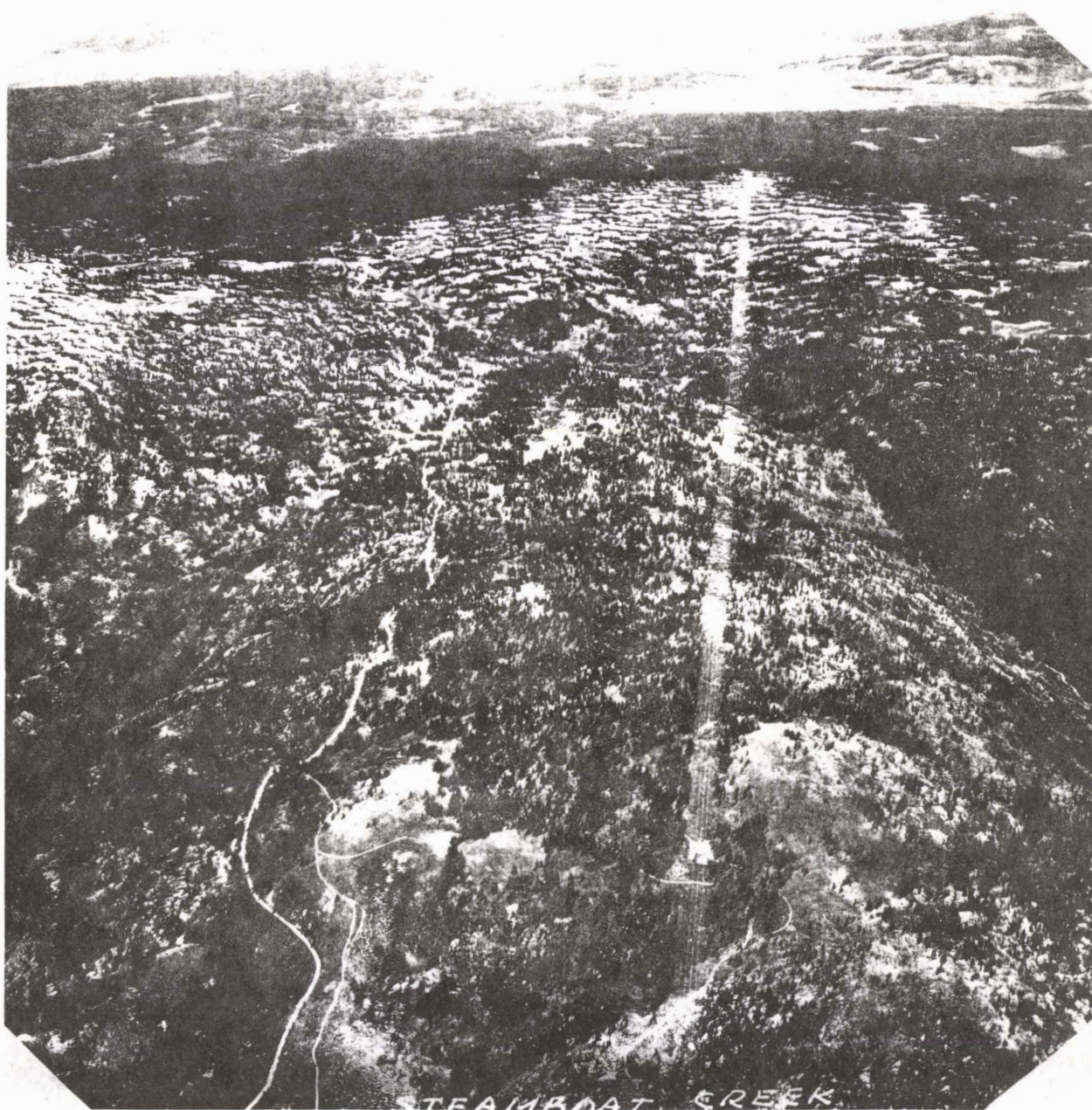


Figure 23.--Narrow strips of spruce-fir near the Continental Divide on Fish Creek. These strips play a significant role in snowpack accumulation. The thick timber near the top of the photograph is the headwaters of Grizzly Creek, which flows through North Park. Fish Creek stream gage is located just to the left of the powerline on the tributary which cuts diagonally across the photograph.

South Fork of Soda Creek

The headwaters of Soda Creek is in the alpine park type, as is the headwaters of Fish Creek. The parks are interspersed with strips of spruce-fir peculiar to this part of the Park Range. Below 10,300 feet, the forest blends into the more typical block pattern spruce-fir type.

According to Wilford (1967), a substantial area of Soda Creek was burned over by the 1879 fire. Aspen has replaced much of the original spruce-fir and Douglas-fir forest on the north slopes. Lodgepole pine is also filling in on the south exposures below 9,000 feet.

The rock outcrops in the immediate vicinity of the weir support a rugged stand of spruce-fir with a mixture of aspen and shrubs. The areas within the stream bottoms, on the ridges, and on the rocky slopes below 10,000 feet, are poorly stocked with spruce and fir trees.

GEOLOGY

General

The bedrock in the north end of the Park Range test area is composed of extensively fractured and faulted granite, and interlayered schists, gneisses, amphibolites, and metasediments. On the south end, in the vicinity of Highway 40, basalt and related igneous rocks are found in isolated patches along valley bottoms and ridges (Dirmeyer 1967).

The depth of weathering increases from north to south and is related to past erosion in the area (Dirmeyer 1967). The relatively fresh unweathered bedrock in the north end of the test area is due to extensive glacial activity and subsequent erosion by streams. In the south end of the target area, the metasediments are deeply weathered, and generally covered by basaltic flows or glacial debris.

According to Dirmeyer (1967), a large part of the topography has been carved into its present form by streams cutting along channels created since later Tertiary time. Thus, the terrain below 10,000 feet in the vicinity of Fish and Soda Creeks, for example, is characterized by many deep and narrow canyons. This contrasts with the rounded mature topography in the upper Walton Creek drainage area.

The Park Range has a history of several stages of glaciation. According to Dirmeyer (1967), the main momentum of the glacial action was apparently from the area north of Buffalo Pass extending southward into the area west of Rabbit Ears Peak. This activity has produced the gentle and rolling terrain along the Continental Divide.

Soda Creek

The bedrock on Soda Creek is entirely of pre-Cambrian origin. Three main bedrock types are present: metasediment, granite, and biotite gneiss with amphibolite (Dirmeyer 1967). For the most part, the rocks are unweathered, and although well-fractured, almost water-tight.

Soils on the watershed are sparse apparently due to intense glacial activity and high intensity runoff, particularly in the lower reaches of Soda Creek.

Groundwater storage on Soda Creek is limited to: (1) talus mantles on the steep hillside slopes of lower Soda Creek, and (2) the relatively deeper soil mantle in upper Soda Creek. Surface storage is negligible, and occurs as small shallow lakes along the perimeter of upper Soda Creek.

Fish Creek

The bedrocks on Fish Creek are pre-Cambrian granite, interlayered biotite schist, biotite gneiss, and amphibolite. The conditions of soil mantle, depth of weathering, and bedrock fracturing are all similar to Soda Creek. Groundwater and surface storage on Fish Creek are negligible.

Walton Creek

The geology and soils on Walton Creek place this watershed in a different hydrologic unit. The bedrock is a mixture of deeply weathered pre-Cambrian metasediments and late Tertiary age basalt (Dirmeyer 1967). Walton Creek did not experience glacial activity; therefore, a significant depth of weathered material remains on the watershed.

According to Dirmeyer (1967), recent-age basalt flows occupy both valley bottom and ridgeline areas of Walton Creek.

From the standpoint of groundwater storage, the capacity of the bedrock and soil mantle is appreciably greater than it is on Fish and Soda Creek watersheds. With the exception of small beaver ponds, no additional surface storage exists on Walton Creek.

SNOWPACK ACCUMULATION IN THE PARK RANGE

Bureau of Reclamation target areas present a contrast in distribution of snow cover, which results from a contrast in topography and snow accumulation. In this connection, it is important to realize that possible augmentation of the snowpack as the result of weather modification will not be uniform over any target area, but will be governed by local topography. Maximum effects of increased snow will be in protected forest openings and natural deposition areas in open terrain. For this reason, it is essential that the snow accumulation pattern on each watershed be known in order to evaluate the effects of increased snow on streamflow response.

To obtain better estimates of watershed snow water equivalent, numerous measurements have been made on the Park Range experimental watersheds since 1968. Routine Soil Conservation Service snow measurements are made in small, open parks protected from prevailing winds (Washichek and McAndrews 1967). We sought to determine how well snowpack accumulation on the watersheds could be estimated from the water equivalent vs. elevation curves derived from the Soil Conservation Service network. These data were compared with transects that had systematic spacing of snow samples and traversed forested and open areas as they were encountered on the watersheds.



Figure 24.--Drift configuration near a strip of spruce on Fish Creek. In general, more snow accumulates in the openings between strips than in the drifts immediately beside the trees. Virtually all of the increased snow in the drifts is offset by large scour holes.

Some transects were run near and through the tree bands near Buffalo Pass. Wind effects are pronounced (fig. 24). The turbulence created by the trees results in less snowpack under and adjacent to the tree bands. What appear to be drifts immediately beside the tree bands actually have shallower snow depth than is found in the openings between rows of trees. It appears that wind is forced beneath the tree canopy to cause scouring of snow and that the protective effect of the foliage is exerted further downwind than obvious to casual observation.

A summary of snow-course measurements is shown in table 4. On Walton and Fish Creeks, snow surveys were made within the watersheds. Snowpack accumulation in the lower elevations of Soda Creek was indexed by measurements along the Buffalo Pass road (table 4). In 1969, an additional 2.9-mile reconnaissance snow course was surveyed in spite of extremely difficult terrain on Soda Creek. The effect of elevation on snow accumulation along this transect was similar to that observed along the Buffalo Pass road. Table 5 compares snow measurements on Soda Creek with water equivalents observed at snow courses along the Buffalo Pass road. Several of the snow courses along the Buffalo Pass road are located in protected openings; thus at some elevations, somewhat greater amounts of snow accumulation were observed than along the transect which sampled both forested and open areas as encountered on Soda Creek.

Table 4.- Snow Survey Summary

Park Range, Colorado

Snow course	:	:	1968			:	1969			:	1970			:
	Elev.:	:	Ave.:	Ave.:	No.:	:	Ave.:	Ave.:	No.:	:	Ave.:	Ave.:	No.:	
	:	:	Date	depth	W.E.:	pts.:	Date	depth	W.E.:	pts.:	Date	depth	W.E.:	pts.:
	Ft.			-	Inches	-		-	Inches	-		-	Inches	-
<hr/>														
<u>Walton Creek</u>			4/2				4/3				4/14			
High South Slope	9,500			69.6	26.0	75		69.0	26.7	76		90.0	32.5	44
Low South Slope	9,300			70.7	27.1	30		71.7	28.0	32		85.3	30.9	30
North Slope	9,400			74.5	26.8	48		74.2	27.4	45		86.3	32.6	61
False Top	9,400							77.1	30.2	10		97.0	38.4	5
Average				71.6	26.6	153		73.0	28.1	163		89.6	33.6	140
<hr/>														
<u>Fish Creek</u>			4/4				4/2				4/15			
Peak	10,700							117.4	46.6	10		150.1	60.4	7
Upper Fish Creek	10,500			106.7	40.6	24		100.5	39.5	10		141.1	53.8	7
So. Summit Lake	10,200			109.0	38.5	24		128.8	51.0	10		148.3	58.8	6
Below Tower	10,400			103.6	40.0	12		115.9	47.2	10		165.1	64.6	7
North Slope	10,300			111.5	41.5	32								
South Slope	9,900			104.3	38.8	12								
Streamgage	9,800							107.6	44.6	10				
Average				107.0	39.9	104		114.0	45.8	50		151.2	59.4	27
<hr/>														
<u>Soda Creek</u>			4/3				4/2				4/15			
S-3	10,150			103.2	36.7	24		115.2	46.3	10		143.0	54.5	5
Rocky Flats	9,400			85.6	31.2	25		83.0	32.3	10		104.2	39.0	5
S-2	9,200							77.1	29.8	10		89.1	31.3	5
Near SCS														
Quaker Ridge	8,900			69.4	24.5	12		71.8	26.7	10				
Near Dry Lake	8,450			60.2	19.9	10		70.9	24.8	10		76.9	26.8	5
Near Streamgage	8,200			59.3	21.1	7								

Table 4

Table 4.--Snow Survey Summary (cont.)

Park Range, Colorado

Snow course	Eleva- tion Feet	1971			1972			1973					
		Date	Ave. : :depth	Ave.: W.E.: pts.	Date	Ave. : :depth	Ave.: W.E.: pts.	Date	Ave. : :depth	Ave.: W.E.: pts.			
		- Inches -			- Inches -			- Inches -					
Walton Creek		4/14			3/29			4/3					
High South Slope	9,500		83.6	34.7	42		71.2	26.0	128				
Low South Slope	9,300		74.8	32.8	28		72.3	26.1	29				
North Slope	9,400		78.8	33.6	53		77.6	25.5	47				
False Top	9,400		85.0	37.3	5		82.6	29.6	5				
Streamgage									72.0	26.6	5		
									75.0	26.5	5		
Average			80.5	34.6	128		75.9	26.8	209		73.5	26.5	10
Fish Creek		4/14				3/29				4/4			
Peak	10,700		131.8	58.6	5		118.0	46.1	7				
Upper Fish Creek	10,500		137.0	63.4	5		120.4	47.3	7				
So. Summit Lake	10,200		93.0	66.4	5		120.0	48.2	7		98.2	39.6	5
Below Tower	10,400		136.6	61.2	5		125.7	50.9	7		98.8	37.2	5
North Slope	10,300												
South Slope	9,900												
Streamgage	9,800		109.6	51.6	5		105.0	39.2	5				
Average			121.6	60.2	25		117.8	46.3	33		98.5	38.4	10
Soda Creek		4/14				3/29				4/4			
S-3	10,150		127.6	56.6	5		117.0	42.9	6		101.4	39.5	5
Rocky Flats	9,400		82.6	37.0	5		81.0	29.3	7		76.6	29.2	5
S-2	9,200		74.6	32.0	5		77.2	28.4	5		72.1	26.5	5
Near Quaker Ridge	8,900		67.0	27.4	5		76.8	26.1	6		64.4	24.0	5
Near Dry Lake	8,450		59.0	24.1	5		69.0	24.6	6		57.6	22.1	5
Near Streamgage	8,200												

Table 5.--Comparison of snow water equivalent on Soda Creek
with that observed along Buffalo Pass Road, April 2, 1969

Elevation	Soda Creek Transect	Buffalo Pass Snow Course
<u>Feet, m.s.l.</u>	- - - - - <u>Inches</u> - - - - -	
9,000	28.3	26.7
9,200	25.2	29.8
9,400	28.2	32.3
9,800	38.4	44.6
10,200	40.8	46.3
10,500	41.0	39.5

Similarity of the snowpack according to elevation between years was checked by normalizing all snow courses to one elevation. Our measurements at the 10,150-foot elevation on Buffalo Pass were arbitrarily chosen as the standard. Table 6 summarizes 3 years of normalized data comparing several elevations above and below 10,150 feet. Figure 25 summarizes these results graphically.

In all of the study watersheds, basin-wide sampling revealed more snow at lower elevations than estimated by the elevation-water equivalent relationships derived from valley and ridge crest stations of the regular Soil Conservation snow course network (Washichek and McAndrews 1967, 1970). Apparently, the relationship based on the regular SCS snow course network indicates a more rapid decrease in water equivalent with decreasing elevation than actually occurs from 10,700 to 9,000 feet. A comparison of relationships derived from our surveys with the SCS curve is shown in figure 26. Smoothed snowpack accumulation profiles for 1968-70 are shown in figure 27.

On Walton Creek, snow accumulation was found to be rather uniform at all elevations (table 4). The SCS Rabbit Ears snow course appears to be a reliable indication of average snowpack accumulation on Walton Creek.

Table 6.--Comparative snow course data normalized to the
10,150-foot elevation for 1968-70. Seasonal water equivalent
relative to that at 10,150 feet.

Elevation <u>Ft. m.s.l.</u>	April 3, 1968	April 2, 1969	April 15, 1970
8,450	1.7	1.7	1.7
8,900	1.7	1.7	1.7
9,400	1.4	1.4	1.4
10,150	1.0	1.0	1.0
10,300	1.0	1.0	.9
10,400	1.0	1.0	1.0

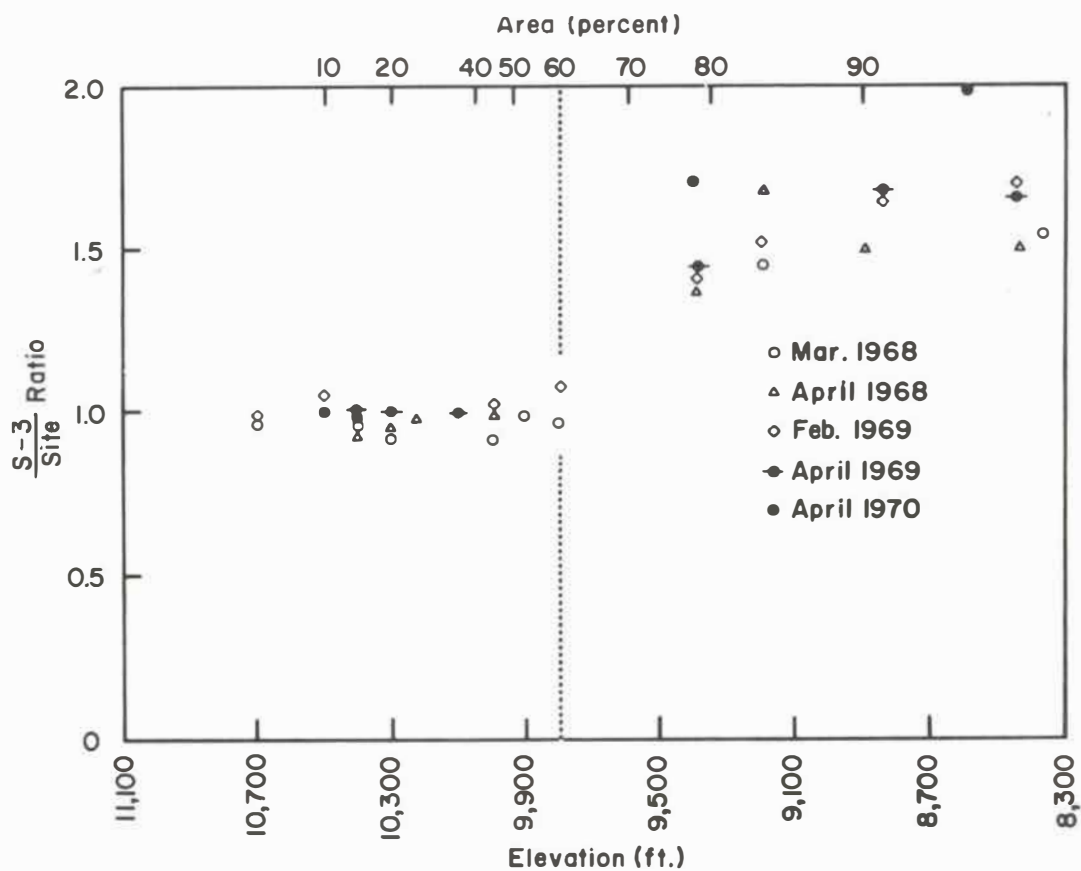


Figure 25.--Comparative snow course data normalized to the 10,150-foot elevation (S-3) for 1968-70.

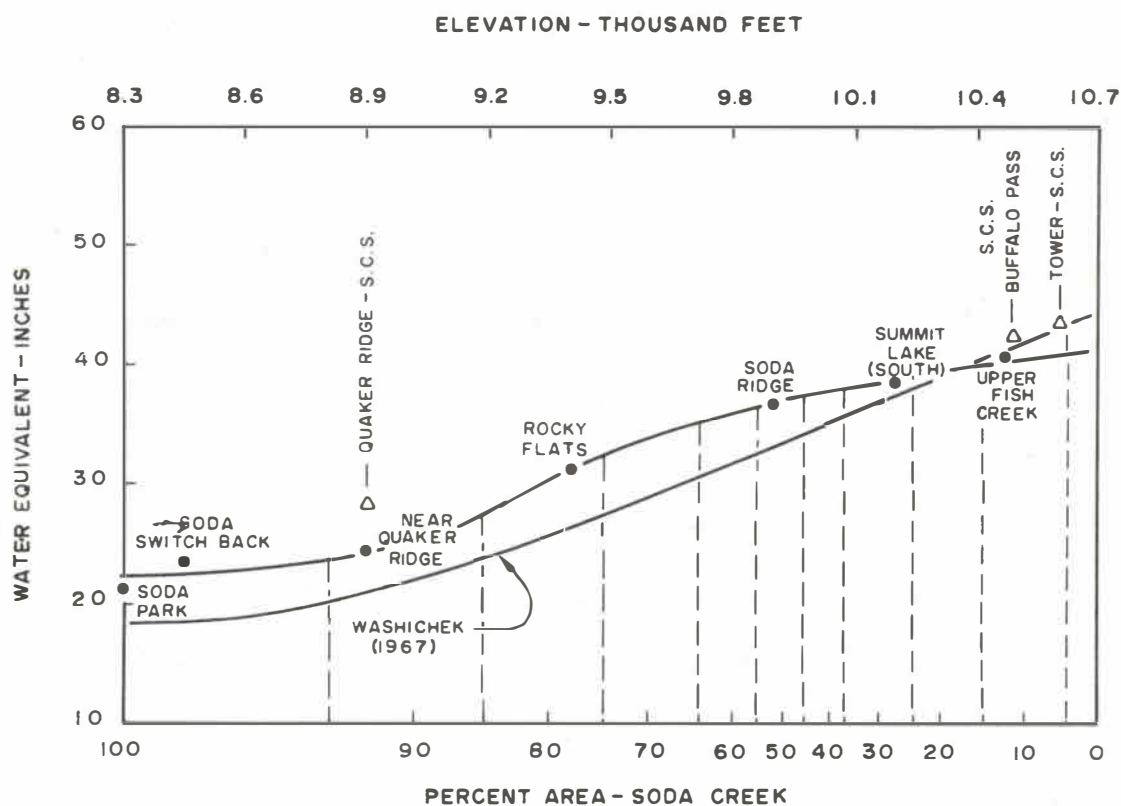


Figure 26.--Comparison of estimated snowpack accumulation with elevation based on Forest Service surveys in 1969 with that proposed by Washichek (1967). Soil Conservation snowcourse readings of April 2, 1969 are also plotted.

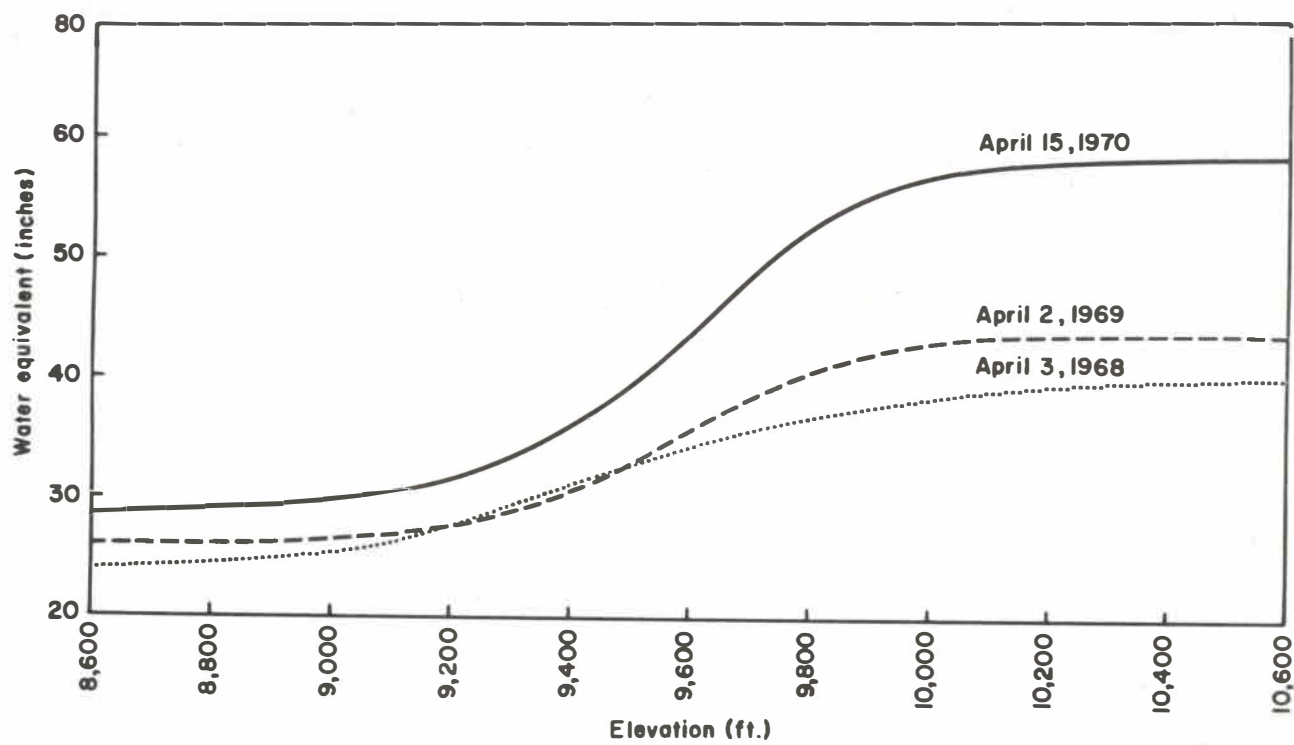


Figure 27.--Smoothed snowpack accumulation profiles 1968-70.

The following tabulation summarizes area-mean water equivalents derived from our April 1968 snow surveys by an area-elevation weighting procedure. Corresponding values, based on the SCS elevation-water equivalent relationship are also tabulated for comparison.

Watershed	Water equivalent estimated from transects	Water equivalent estimated from SCS relationship
	- - - - <u>Inches</u> - - - -	
Fish Creek	39.8	38.7
Walton Creek	26.6	23.8
Soda Creek	35.1	32.7

PRECIPITATION DURING SNOWMELT SEASON

Precipitation has been measured in the experimental area since 1967 in order to determine inputs after the snowpack began to melt and during the summer and fall months. Weekly measurements from standard 8-inch cans are summarized in tables B-1-B-6, Appendix B. In 1968, recording rain gages were installed. Two recorders were located in protected openings along the Buffalo Pass road. A third was on "False Top" near U.S. Highway 40 in the Walton Creek drainage. Tables B-7-B-12, Appendix B, summarize these measurements.

STREAMFLOW

The streamgaging program on the newly established experimental watersheds began on April 5, 1967, when Soda Creek weir was put into operation. The weirs on Walton Creek and Fish Creek were opened up on April 14 and May 5, respectively. These dates closely correspond with the beginning of snowmelt runoff on each watershed. Seasonal hydrographs for 1967 are plotted on figure 28. Table 7 summarizes precipitation and runoff for the 1967-70 record period. More complete records and streamflow are given by Leaf and Brink (1972a), who summarized daily runoff from the three watersheds for the 1967-71 snowmelt seasons.

The marked concentration of high flows from the Park Range is illustrated in figure 29, which shows the monthly distribution of water yields from May to September 1967. Runoff during May and June accounted for 93, 80, and 88 percent of the May-September flow on Walton, Soda, and Fish Creeks, respectively. Figure 30 shows the recession curves for each watershed. Walton Creek is capable of storing considerably more water than Soda or Fish Creeks, and Soda Creek appears to have somewhat less storage capability than Fish Creek.

Because upper Soda Creek and Fish Creek are contiguous and physiographically similar, it is useful to compare the results from both watersheds to determine the relative contributions of snowmelt runoff above and below 9,800 feet, which is the elevation of Fish Creek streamgage.

Table 7.--Precipitation and runoff summary for the Park Range

Experimental Watersheds

Stream	Peak snowpack water equivalent	Subsequent ^{1/} precipitation	Total precipitation	Gaged ^{2/} runoff
----- Inches -----				
Fish Creek				
1967	44.4	14.38	58.8	43.9
1968	49.0	14.08	63.1	44.2
1969	43.2	26.87	70.1	45.2
1970	59.4	18.33	77.7	53.4
Soda Creek				
1967	39.7	12.74	52.4	37.1
1968	42.1	12.88	55.0	36.8
1969	35.8	24.48	60.3	35.4
1970	49.1	16.98	66.1	41.9
Walton Creek				
1967	28.8	11.00	39.8	21.3
1968	34.2	15.48	49.7	28.8
1969	28.1	19.16	47.3	22.8
1970	33.6	18.77	52.4	29.3

^{1/} Precipitation subsequent to peak snowpack estimated from several rain gages in the experimental area. These observations terminate each winter when the stream gaging stations are closed down.

^{2/} Runoff was gaged from early spring to late fall as follows:

Stream	Period of Record			
	1967	1968	1969	1970
Fish Creek	5/10-10/25	5/9-10/10	4/23-10/15	5/12-10/7
Soda Creek	4/5-10/26	4/17-10/17	4/2-10/15	4/16-10/13
Walton Creek	4/14-10/26	4/18-10/16	4/17-10/15	4/21-10/12

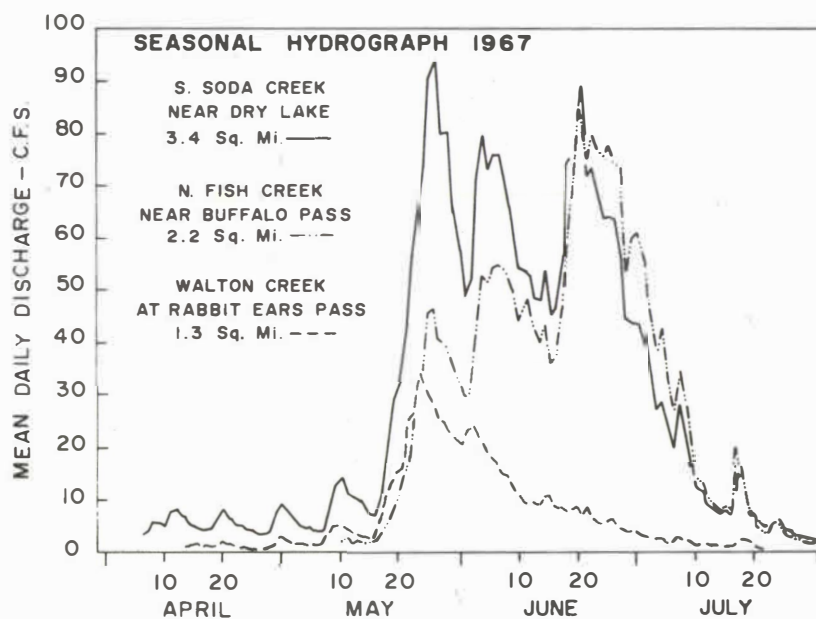


Figure 28.--Comparison of seasonal hydrographs from Soda, Fish, and Walton Creeks, 1967.

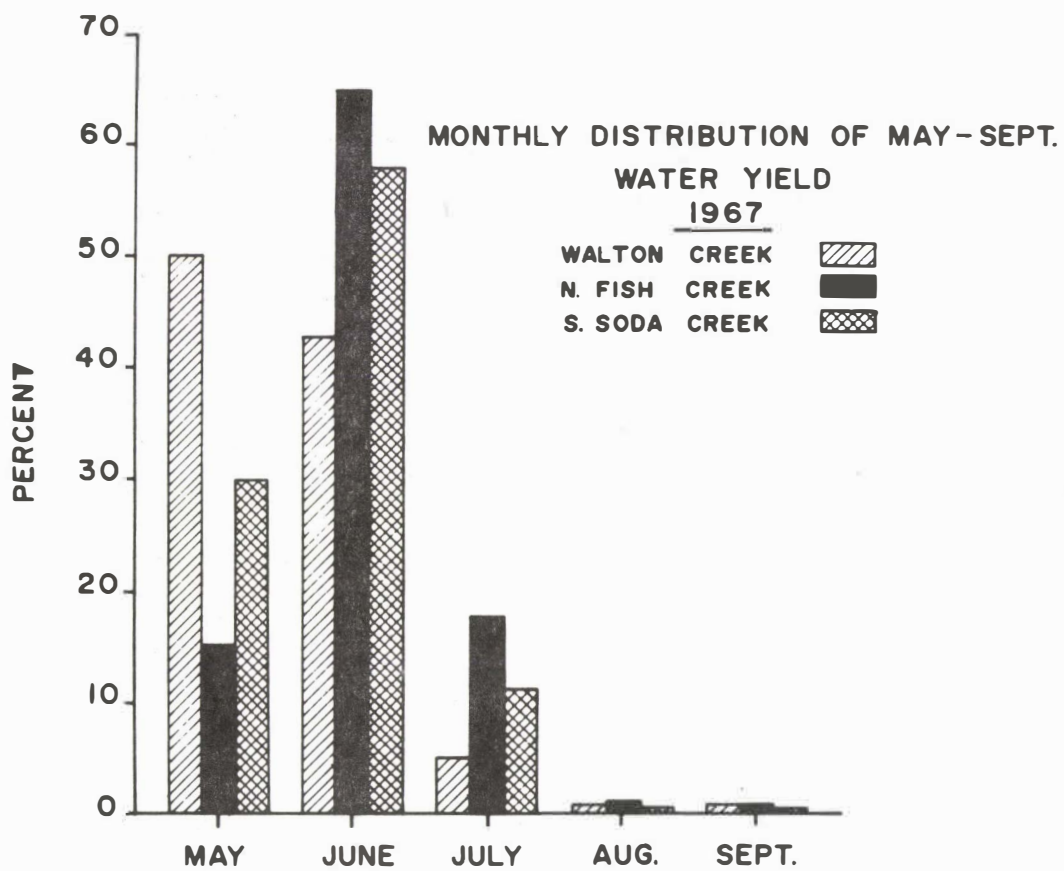


Figure 29.--Monthly distribution of May-September water yields
from the Park Range experimental watersheds.

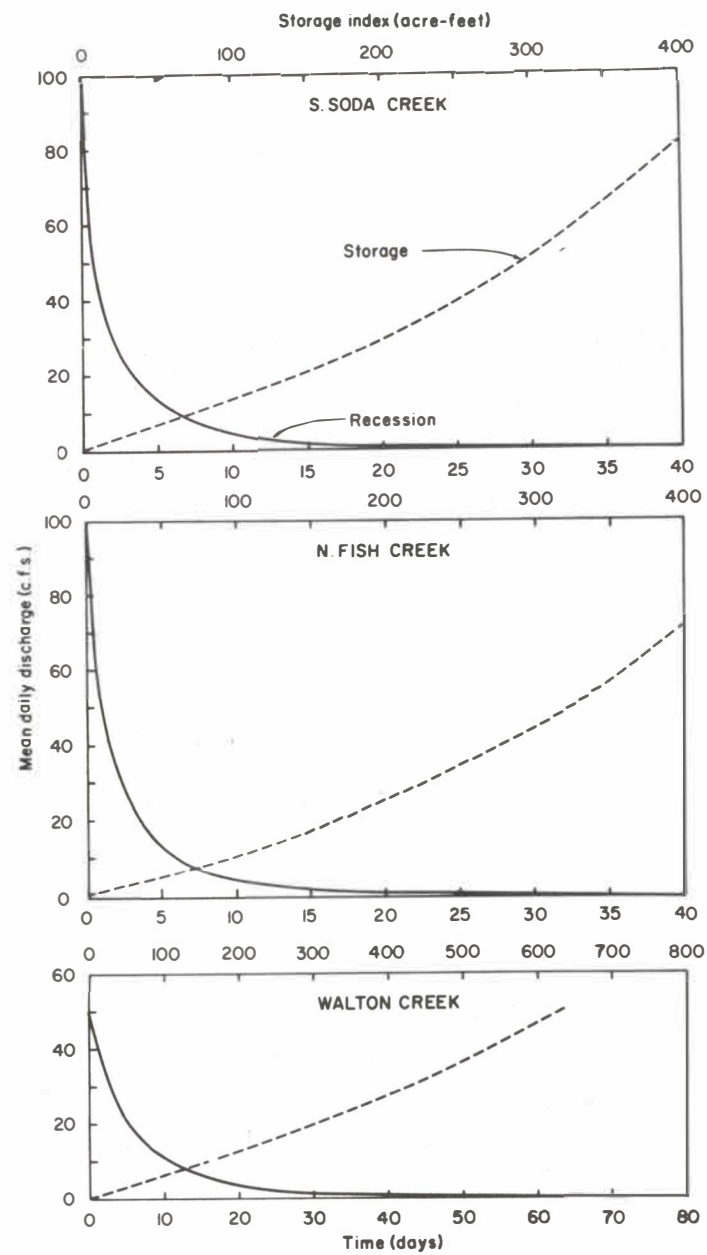


Figure 30.--Recession and storage index curves for the Park Range experimental watersheds.

In this analysis, the assumption was made that flows generated from Fish Creek correspond to like volumes from Soda Creek above 9,800 feet. The flows generated during each of three intervals during the 1967 snowmelt season: (1) April 1 to June 1, (2) June 1 to June 14, and (3) June 14 to July 31 are discussed here.

Lower Soda Creek began to deplete its snow cover relatively early in the spring. By mid-June, only remnants of the snowpack remained, covering about 25 percent of the total area. Lower Soda Creek, which makes up 57.8 percent of the watershed area, contributed all of the water in the first rise of the stream before May 18 (fig. 28). During the interval between May 18 and June 1, contributions from Lower Soda (below 9,800 feet) were almost twice Upper Soda; however, between June 1 and June 14, Lower Soda contributed only 60 percent of the runoff. By mid-June, Lower Soda contributed only 20 percent to the snowmelt hydrograph.

It is interesting to note further that the area below 9,800 feet contributed the largest share of the primary peak on Soda Creek. This initial peak, which occurred on May 26, coincided with that of Walton Creek. On June 20, Soda Creek produced a secondary peak, which resulted for the most part, from snowmelt above 9,800 feet. This secondary peak coincided with that of Fish Creek and was nearly as large.

A comparison of total seasonal flows with peak snowpack and precipitation measurements for 1967-70 (table 7) indicates that the efficiencies of the Fish and Soda Creeks watersheds are high, averaging almost 70 percent for the 4-year record period. This compares with an average 55 percent for Walton Creek. Thus, it appears that the potential for producing additional streamflow from possible weather modification attainments is exceptionally high in the Buffalo Pass area of the Park Range.

SNOW COVER DEPLETION

Aerial photographs of the extent of snow cover were taken in the Park Range during the 1966-71 snowmelt seasons. The photographs were obtained under contracts with a private contractor. Oblique photographs were taken through the 1966 snowmelt season. In 1967-70, we contracted for uncontrolled 9- by 9-inch vertical photographs with a photo scale of about 500 feet to the inch.

Snow-covered areas observed on the photographs were delineated on subdivided base maps of each watershed. Watershed subdivisions were selected on the basis of orientation, steepness, and vegetation. The subunits are homogenous: that is, the conditions of snowpack are uniform within each unit and change more or less abruptly between units. The maps (figs. 12, 14, and 16) show the several subunits. The amount of snow cover in each subunit was estimated visually with the aid of a folding stereoscope. The total snow cover on a given flight date was determined by means of a weighted average based on the size of the various watershed units and the estimated snow cover in each.

Extent of snow cover in the Park Range watersheds is summarized in tables 8 and 9.

Table 8.--Summary of areal snow cover

1966-68 snowmelt runoff seasons

Date	Percent snow-covered area		
	Walton Creek	Soda Creek	Fish Creek
1966			
April 30	100	100	100
May 18	75	80	100
May 23	35	70	100
May 29	5	55	95
June 6	0	40	60
June 23	0	5	5
1967			
April 28	100	96	100
May 16	100	94	100
June 2	78	80	100
June 17	8	65	99
June 23	3	46	92
July 2	0	22	49
1968			
May 28	100	97	100
June 3	100	85	100
June 9	81	80	100
June 19	35	69	99
June 29	4	--	--
July 5	0	18	40
July 13	--	4	6

Table 9.--Summary of areal snow cover

1969-71 snowmelt runoff seasons

Date	Percent snow-covered area		
	Walton Creek	Soda Creek	Fish Creek
1969			
May 10	100	92	100
May 15	91	86	100
May 25	40	74	100
June 4	6	58	96
July 2	0	5	14
1970			
June 2	100	90	100
June 21	32	66	99
July 1	5	39	68
July 15	0	1	2
1971			
June 12	88	85	100
June 23	27	57	93
July 8	5	16	34
July 11	0	7	17

Depletion of the snow cover tends to be prolonged in watersheds with diverse terrain. This is true of Soda Creek, whose lower part exhibits a greater variability in topographic characteristics than the upper part. Below about 9,800 feet there is a greater variation in steepness of slopes, greater relief, and greater dispersion of slope orientation. Accordingly, more subunits in lower Soda Creek begin to lose snow early in the melt season, but many of these areas still retain snow late in the season. The long depletion period of around 120 days on Soda Creek contrasts with less than 50 days on Walton and Fish Creeks.

A marked acceleration in depletion subsequent to considerable melt of a continuous pack has been clearly observed in all units comprising Fish Creek. This tendency is characteristic of snowpacks of rather uniform depth subject to uniform melting rates. It is significant that it appears in the gentle and rolling terrain along the Continental Divide. Comparisons of snow-cover depletion on the Park Range experimental watersheds during the 1967 snowmelt runoff season are shown in figure 31.

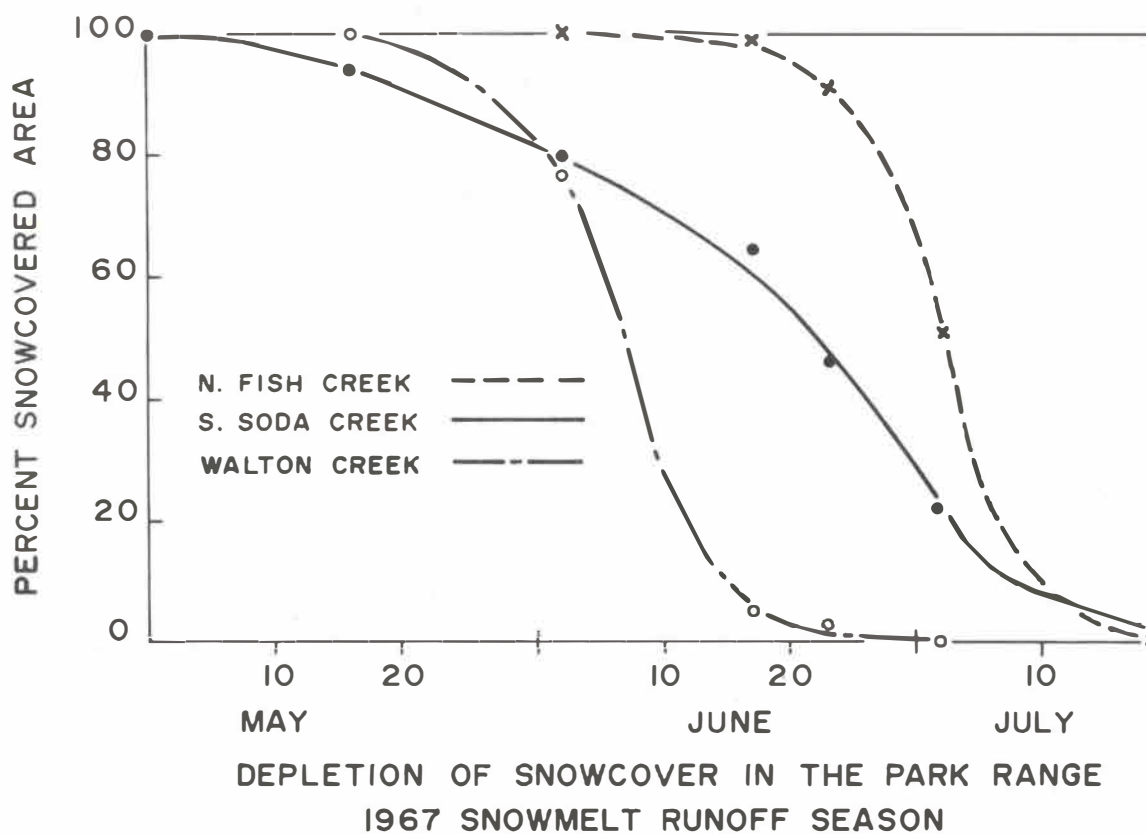


Figure 31.--Comparisons of snow-cover depletion on Park Range experimental watersheds during the 1967 snowmelt runoff season.

WATERSHED SYSTEMS ANALYSIS - SNOWMELT SIMULATION

Systems analysis is an efficient way to determine the probable effects of weather modification on the many interdependent components which comprise subalpine hydrology. Accordingly, a comprehensive mathematical model was developed with the objective of realistically simulating snowmelt and runoff from Bureau of Reclamation target areas.

Hydrologic components simulated are: (1) winter snow accumulation, (2) the energy balance, (3) snowpack condition, (4) snowmelt, and (5) resultant water yield in time and space under a variety of environmental conditions. These conditions include any combination of: (1) aspect, (2) slope, (3) elevation, and (4) forest cover composition and density. The program has been referred to as the "Subalpine Water Balance Simulation Model." It simulates the water balance in hydrologic response units within a subalpine watershed on a continuous year-round basis, and compiles the results from up to 25 units into a "composite overview " of the entire drainage area. Generated flows are routed through the basin by means of storage routing procedures. Flow chart descriptions and pertinent hydrologic theory have been published by Leaf and Brink (1972 b,c, 1973a,b) and Brink and Leaf (1973). The reader is referred to these papers for detailed discussions of the scope and operation of the model. A general flow chart of the system is shown in figure 32.

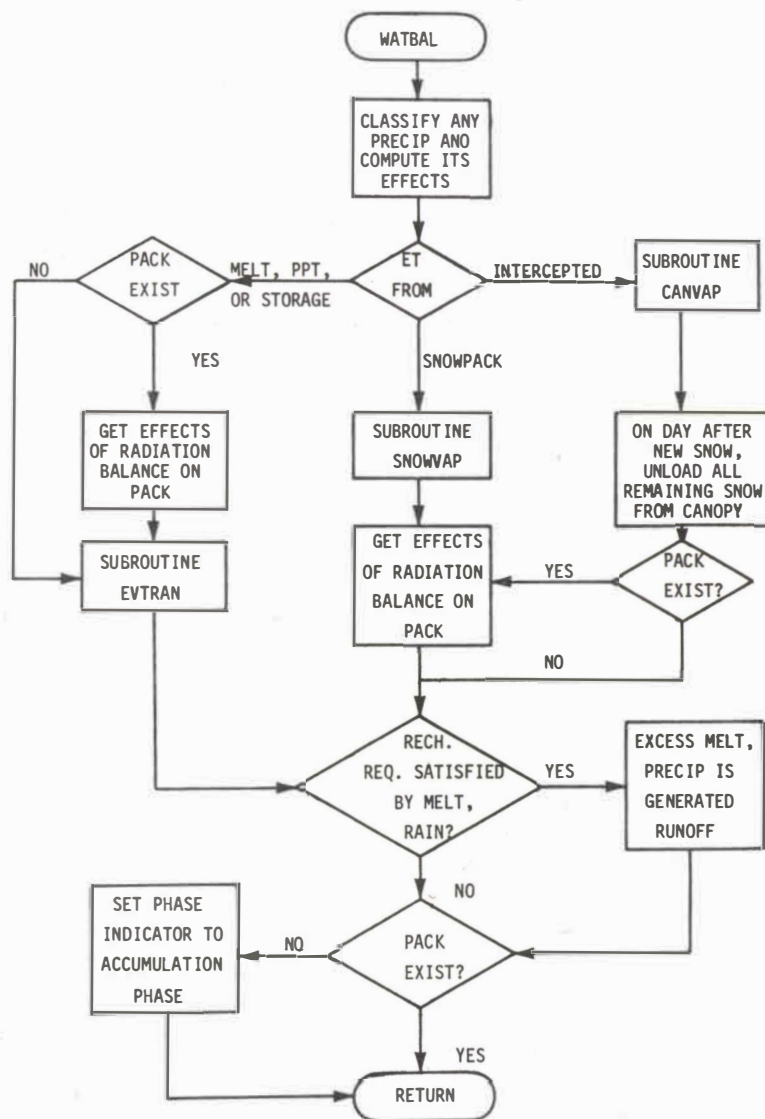


Figure 32.--General flow chart of Subalpine Water Balance Simulation Model.

Work with the Subalpine Water Balance Simulation Model has produced preliminary results concerning the probable hydrologic effects of additions to the winter snowpack through weather modification in the Park Range.

SIMULATED SNOWPACK INCREASE AND RESULTANT WATER YIELD FROM SOUTH SODA CREEK

Runoff from the south fork of Soda Creek (fig. 12) was simulated in order to define the probable effects of weather modification in the Park Range. Figure 33 compares simulated and observed discharge hydrographs for the 1968 snowmelt runoff season.

Hydrologic Subdivisions.--Soda Creek was divided into 10 subdivisions. Further division of forest and open areas resulted in 23 response units used for the simulation analysis. The pertinent geographic characteristics of each response unit are summarized in table 10.

Temperatures.--The long-term climatological station at Steamboat Springs was used as a base station for estimating daily temperature extremes in each of the 23 response units. These estimates were based on prediction equations developed from correlation analyses between Buffalo Pass and Steamboat Springs for 1968.

Solar Radiation.--Because reliable long-term radiation data are not available in the Buffalo Pass area, the shortwave radiation input to the model was generated from potential solar beam radiation as a function of temperature and the slope-aspect characteristics of a given response unit. In order to compute an index of incident

Figure 33.--Comparison of observed and simulated hydrographs from
Soda Creek during 1968 snowmelt runoff season.

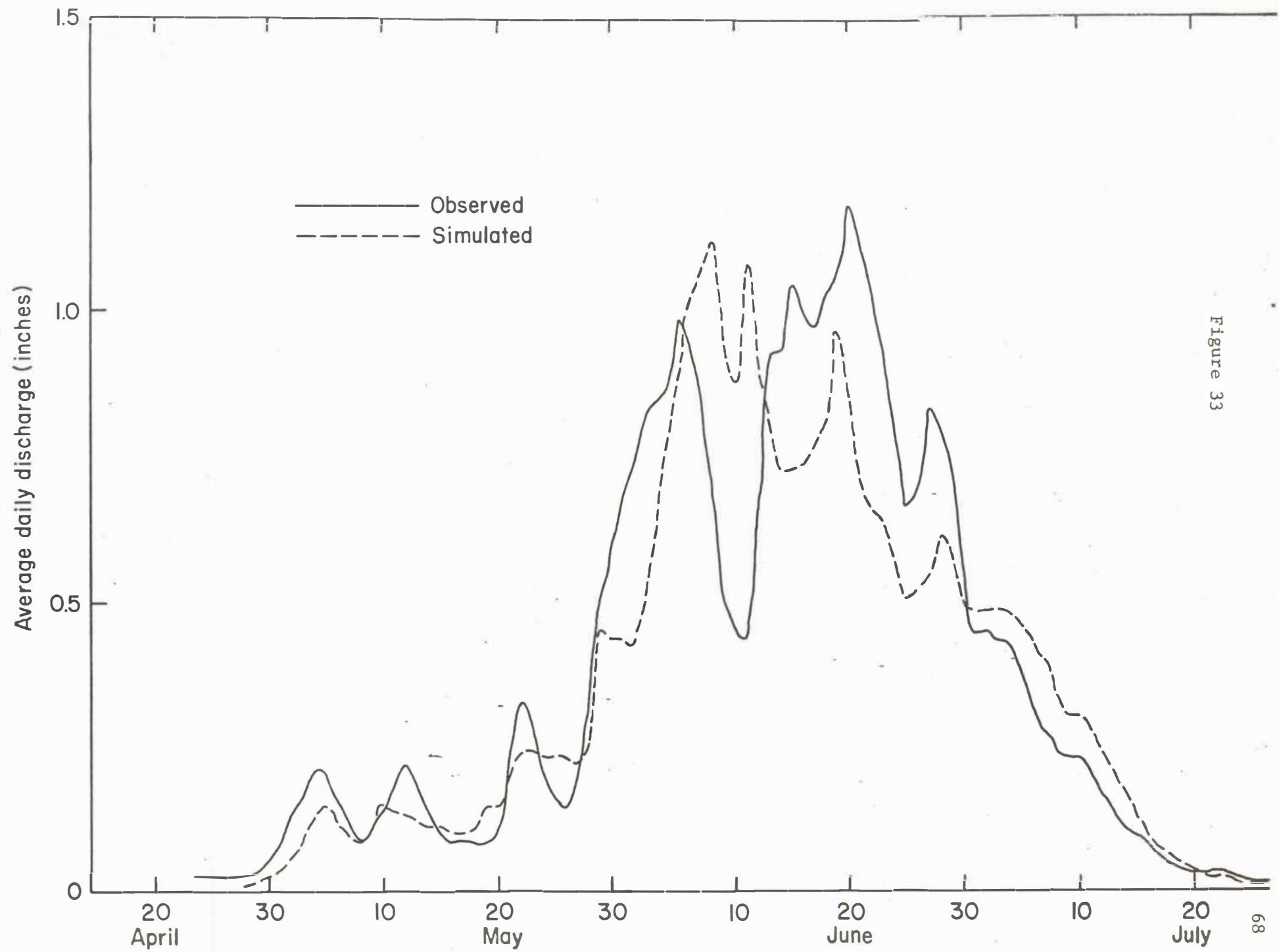


Figure 33

Table 10.--Geographical description of South Soda Creek drainage basin

Sub-unit	Area (acres)	Percent total area	Response unit code	Percent subunit	Percent basin	Average elevation (feet)	Average aspect	Average slope (%)	Forest cover type ^{1/}	Cover density (%) ^{2/}
1	195.7	9	1AS-0	72	6	9,100	S	35	A	15
			1FS-0	28	3				SF	20
2	173.9	8	2FS-0	34	2	9,900	S	27	SF	20
			2ØS-0	57	5				Ø	
			2AS-0	9	1				A	15
3	195.7	9	3FS-160	54	5	10,400	S	36	SF	20
			3ØS-160	46	4				Ø	
4	130.4	6	4FS-192	52	3	10,650	SW	10	SF	20
			4ØS-192	48	3				Ø	
5	239.1	11	5AS-WTW	4	1	10,200	WNW	30	A	15
			5F1S-WTW	33	4				SF	30
			5F2S-WTW	58	5				SF	30
			5ØS-WTW	5	1				Ø	
6	326.1	15	6FS-160	67	10	10,200	SSW	25	SF	15
			6ØS-160	33	5				Ø	
7	195.7	9	7FS-0	17	1	9,800	SSW	35	A	15
			7FS-0	41	4				SF	10
			7ØS-0	42	4				Ø	
8	195.7	9	8F1S-9	73	7	10,150	NNW	20	SF	25
			8F2S-9	27	2				SF	15
9	282.6	13	9ØS-45	31	4	9,850	N	27	Ø	
			9FS-45	69	9				SF	25
10	239.1	11	10ØS-76	100	11	9,200	NNW	32	Ø	
Sum	2174	100			100					

^{1/} A = Aspen; SF = Spruce-fir; Ø = Open

^{2/} C_D_{Max} = 65 for Spruce-fir and 30 for Aspen

short-wave radiation received each day, the model adjusted potential radiation downward by means of a thermal factor. This factor was determined by degree-day relationships which vary according to the season of the year.

Precipitation.--Peak snowpack accumulation on Soda Creek during 1967-71 have been summarized in table 4. These values and snowcourse data obtained from the Soil Conservation Service were used to develop profiles of peak snowpack accumulation (figs. 26 and 27). To ensure the proper snowpack accumulation as determined by these profiles, the base station daily precipitation (at Steamboat Springs) was adjusted until the specified peak water equivalent on each response unit was reached.

Weather Modification.--Evidence from seeding experiments in the Rocky Mountains has indicated that perhaps 20 to 40 percent of the winter storms are favorable for increasing precipitation. The Bureau of Reclamation's seeding experiments indicated that snow accumulation was in fact increased as the result of cloud seeding in the Park Range. Accordingly, we have made preliminary studies with the Subalpine Water Balance Model to quantify the hydrologic effects of successful weather modification. These studies were based on an assumed 15 percent increase in winter snowfall between November 30 and March 31 of each year.

Table 11 summarizes average results on Soda Creek from a 5-year period of record. An average 5.4 inches of increased water equivalent for 1967-71 produced an average 4.8 inches of additional water yield with a 0.5-inch increase in evapotranspiration. In this case, the increased snow accumulation did not extend the duration of the melt season more than 3 to 5 days. Approximately 90 percent of the increased snowpack produced streamflow. Six-day interval simulations of the major hydrologic components are summarized in Appendix C.

Because water yield benefits result from the last snowmelt at a given location, the bulk of the increased runoff is released during and just after peak streamflow. This broadens the snowmelt hydrograph and increases both peak and recession flows as seen in figure 34, which compares the simulated average hydrograph for 1967-71 under natural conditions with the average hydrograph resulting from a 15 percent increase in winter snow accumulation.

Figure 34.--Simulated hydrographs showing the average effect of a 15 percent snowpack increase on quantity and timing of water yields for 1967-71.

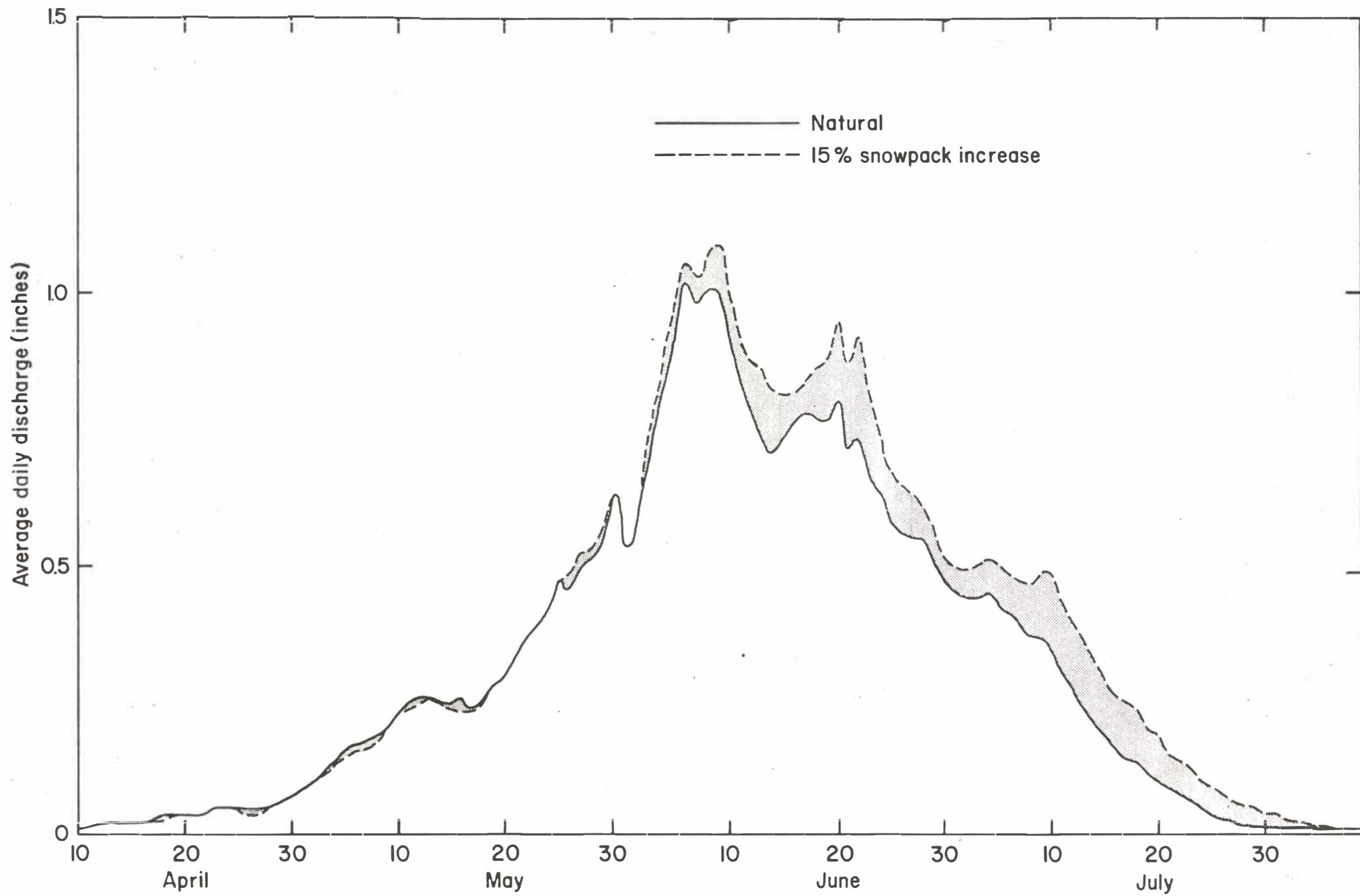


Table 11.--Simulated hydrologic changes resulting from a 15 percent
increase in snowpack between November 1 and March 31,
South Soda Creek, Routt National Forest
Response Unit: Total Watershed

Component	Water balance, in inches		
	Natural	Treated	Change
Precipitation	55.1	60.5	+5.4
Evapotranspiration	16.7	17.2	+0.5
Recharge requirement			
beginning (10/1)	2.1	2.2	-0.1
end (9/30)	2.4	2.4	0
Water yield	38.5	43.3	+4.8

SUMMARY

§ Early records from the Park Range, along with comparative data from the Fraser River drainage in Middle Park, Colorado, provided a basis for the design and construction of prefabricated, lightweight streamgaging structures. Gages were installed and have been successfully operated on three high-elevation watersheds.

Streamflow is concentrated in the snowmelting period and the streams respond rapidly to changes in melt rate. Seasonal peaks are much larger than ordinarily expected from snow-fed streams. Flow recedes rapidly when melting is complete. Eighty to ninety percent of the seasonal runoff takes place in May and June. Walton Creek has somewhat more storage than watersheds in the vicinity of Buffalo Pass.

§ Forest conditions have been strongly influenced by past insect epidemics and the catastrophic fire of 1879. Forest is reestablished or restocked on those areas where it was originally present. The strip-like nature of the forest patches in the upper portions of Fish Creek and Soda Creek and north is a natural feature that has persisted for hundreds of years. The forest patches maintain themselves by regeneration of new trees as old ones die, but do not extend their boundaries into surrounding grasslands. These strip areas were not affected by the 1879 wildfire.

Strips average 45 feet in width and 300 feet in length and distance between strips is a near-uniform 120 feet. Spacing between the ends of strips often is only 15 feet or less. This pattern has an important effect on snow accumulation on the area. Apparently, one reason trees cannot successfully invade the open areas between strips is because of the deep snowdrifts that form there.

§ The bedrock on the Fish and South Soda Creek watersheds is entirely of pre-Cambrian age composed of metasediment, granite, and biotite gneiss. From a hydrologic viewpoint, all three rock types are similar. Each is hard, relatively unweathered, but characterized by extensive fractures and fault zones. The fractures and faults are relatively tight. Apparently, no significant storage capacity for water has been created in these rocks by fracturing or faulting.

Walton watershed is composed of the metasediment rock and basalt. The metasediments there are deeply weathered. Because of this and the porous character of some of the basalt and its jointed structure, there is more capacity for ground-water storage on this watershed.

The three small, gaged watersheds appear representative of the target area so far as geology is concerned. A portion of the headwaters of Fish and Fish Hook Creek may have slightly greater surface and channel storage capacity because of the presence of glacial debris.

§ Snow cover disappearance was studied from vertical air photographs taken at about 2-week intervals during the snowmelt period. Relations between areal snow cover remaining and runoff were established. Each basin was divided into sub-areas based on slope orientation and elevation. Change in snow cover was recorded for these subunits for each set of flight photographs.

On Walton Creek, the snow cover decreased substantially in depth with little change in bare area. It then shrank rapidly in area and large areas became bare at the same time. Fish Creek also shows a marked acceleration in the amount of bare area after considerable ablation of a continuous pack. This tendency is typical of snowpacks of rather uniform depth subject to uniform melting rates.

Soda Creek has a melt pattern typical of basins with a variance of terrain. Below 9,800 feet elevation, there is a wide range of relief, aspect, and steepness. There, more topographic units lost snow early, but others retained snow until late. In 1967, the total period of snow-cover depletion was 120 days compared with less than 50 days on Walton and Fish Creeks.

§ Determination of the effects of weather modification on watershed response requires an accurate estimate of the precipitation input. To obtain better estimates of basin snow water equivalent, numerous measurements were made on the Park Range. Transects were run with systematic spacing of sampling points which traversed forested and open areas as they were encountered on the watersheds.

In all of the study watersheds, the basin-wide sampling revealed more snow at lower elevations than estimated by elevation-water equivalent curves derived by the Soil Conservation Service. Apparently, the relationship based on the regular SCS snow course network indicates a more rapid decrease in water equivalent with decreasing elevation than actually occurs.

The influence of forest cover on snow accumulation must be taken into account in estimating areal snowpack. In this connection, the vegetation in the Park Range plays a vital role in affecting snowpack deposition.

Wind effects near and through the tree bands near Buffalo Pass are pronounced. The turbulence created by the trees results in less snowpack under and adjacent to the strips of timber. What appear to be excessive snow accumulations in deep drifts immediately beside the trees actually have shallower snow depth than is found in the openings between the spruce-fir strips. It appears that wind is forced beneath the tree canopy to cause scouring of snow and that the protective effect of the foliage is exerted for a considerable distance downwind.

§ In the Park Range near Buffalo Pass, there are two characteristic stages of high water on watersheds ranging in elevation from 8,300 to 10,700 feet. The first stage begins early and results from rapid snowmelt below 9,800 feet. This runoff produces peak flows of nearly the same magnitude as later runoff, which comes as the result of high elevation snowmelt. The contribution to streamflow from low elevations is about twice that from upper elevations early in the snowmelt season. During the latter part of the snowmelt season, however, snowmelt below 9,800 feet is only one-fifth of that above this elevation.

Soda and Fish Creeks convert approximately 70 percent of the total input to streamflow. This compares with 55 percent for Walton Creek. Thus, it appears that the Park Range near Buffalo Pass has a somewhat higher potential for producing additional streamflow from possible weather modification attainments.

WATERSHED SYSTEMS ANALYSIS - RUNOFF SIMULATION

§ A comprehensive mathematical model has been developed which represents hydrologic systems in Bureau of Reclamation target areas. Our first approach has been to model: (1) winter snow accumulation, (2) the energy balance during winter and during the spring melt season, (3) condition of the snowpack in terms of temperature and free water, and (4) snowmelt, and (5) runoff in time and space in any environment. The model accounts for the following physiographic variables: (1) elevation, (2) aspect, (3) slope, and (4) forest cover composition and density. The model has been extensively tested with good results using field data collected from representative areas in the central Rocky Mountains.

§ We have used the model to simulate hydrologic response from an assumed 15 percent increase in winter snow accumulation. On South Soda Creek, a simulated increase of 5.4 inches of water equivalent for 1967-71 produced an average 4.8 inches of additional water yield with a 0.5-inch increase in evapotranspiration.

§ Our watershed studies have produced information, which should be helpful in determining the effects of weather modification on snow-cover duration. Mathematical simulation techniques suggest that on Soda Creek in the average year, the snow cover lasts from 3 to 5 days longer with a 15 percent snowpack increase.

§ Because water yield increases result from the last snowmelt at a given location, the bulk of the increased runoff is released during and just after peak streamflow, thus broadening the snowmelt hydrograph and increasing both peak and recession flows.

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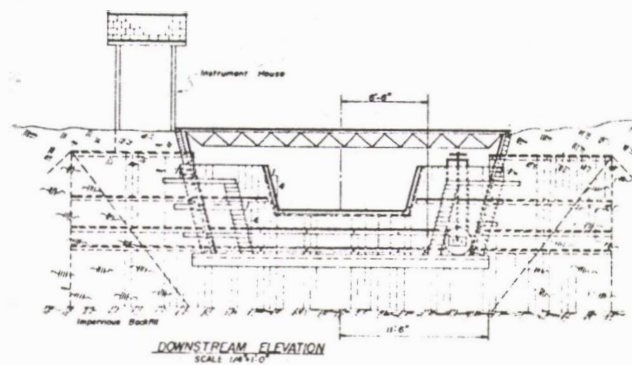
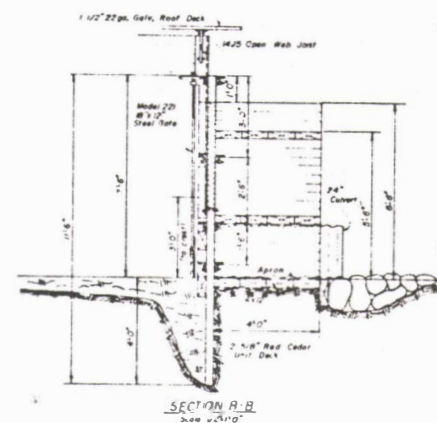
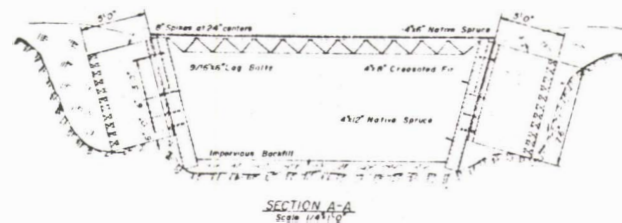
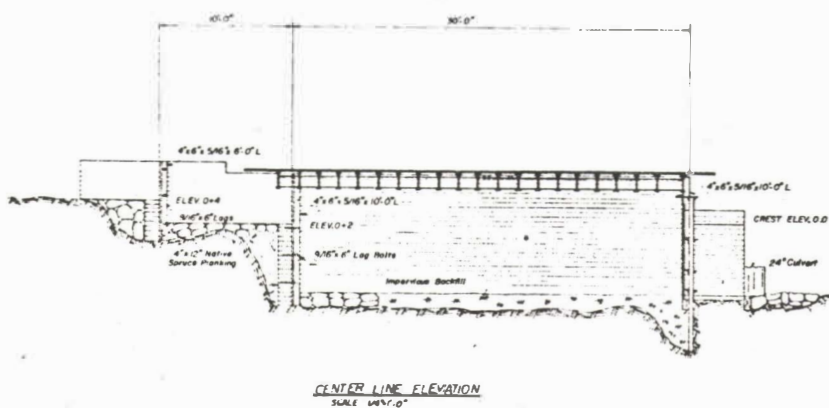
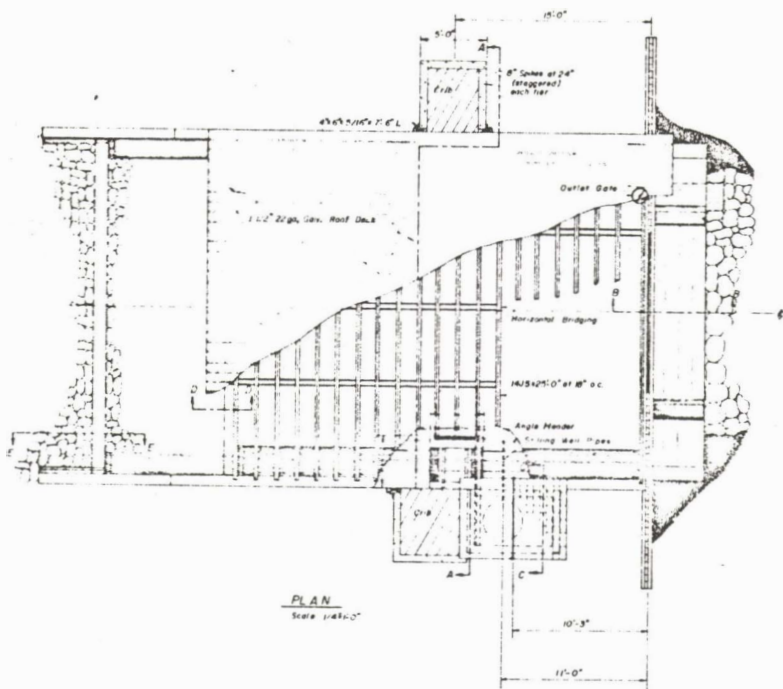
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APPENDIX A

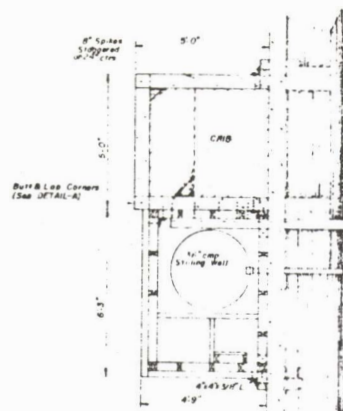
PARK RANGE ATMOSPHERIC
WATER RESOURCES PROGRAM

TYPICAL DESIGN DRAWINGS
FOR CIPOLETTI WEIRS

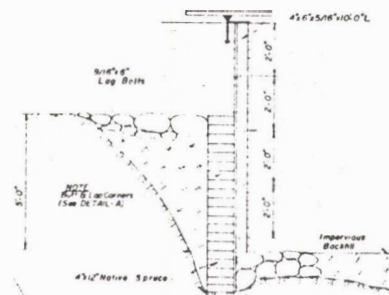


CIPOLLETTI WEIR - GENERAL DESIGN
Sheet 1 - 4

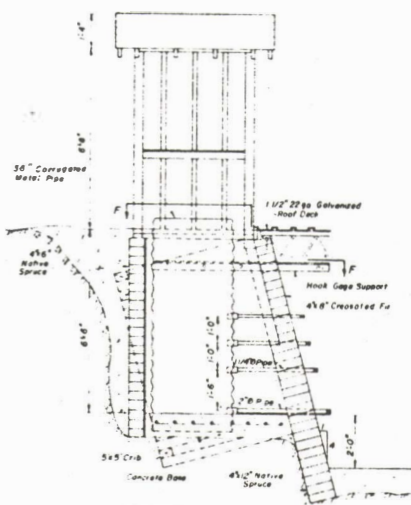
FARK RANGE ATMOSPHERIC WATER RESOURCES PROGRAM
Rocky Mountain Forest & Range Experiment Station
U.S. Department of Agriculture
in cooperation with the
Office of Atmospheric Water Resources
Bureau of Reclamation, U.S. Department of the Interior



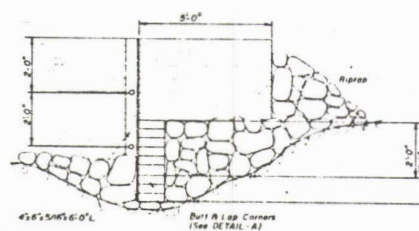
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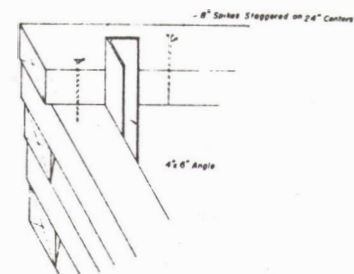


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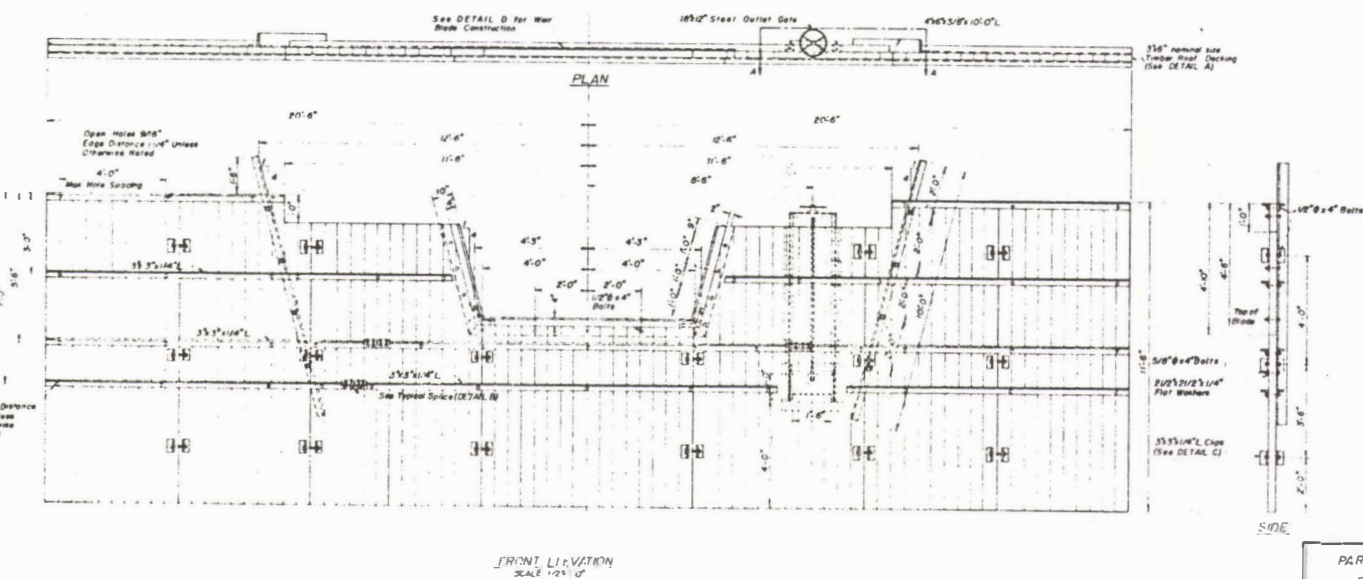


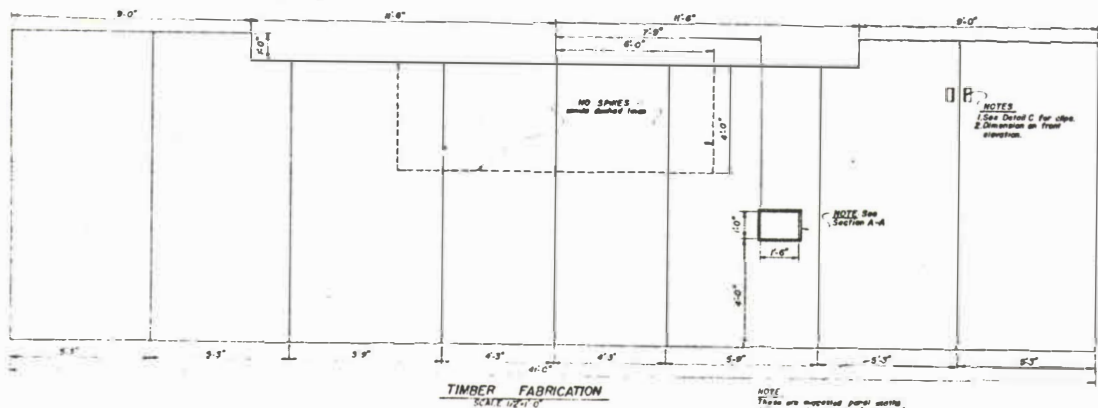
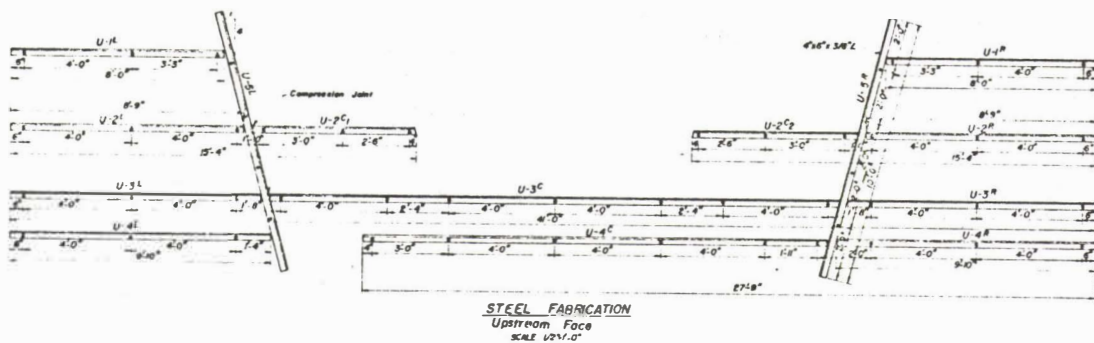
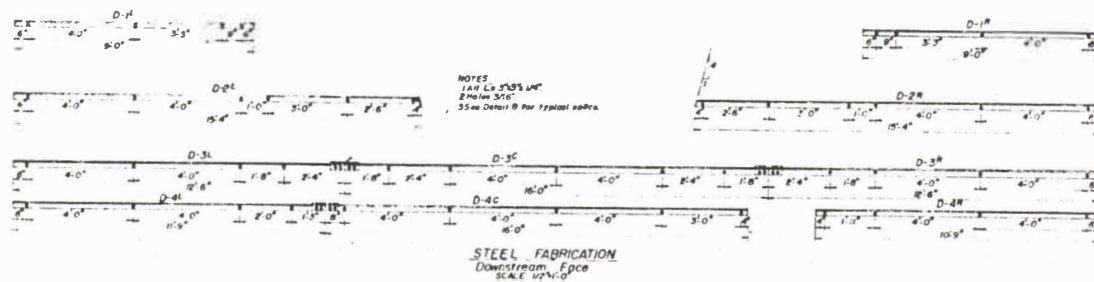
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NOTE:
Spacing of wall strips permitted
provided joints are staggered and
indicated by at least two adjacent
strips to be moved together
with all surfaces staggered on 2\"/>



DETAIL - A





CIPOLLETTI WEIR - GENERAL DESIGN
 Sheet 4-4

APPENDIX B

CLIMATOLOGICAL SUMMARY
Park Range, Colorado

WEEKLY PRECIPITATION - INCHES

SODA CREEK STREAMGAGE, ELEVATION 8,300 FEET

Year	April		May		June		July		Aug.		Sept.		Oct.	
	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.
1967					18-1	1.10	27-5	0.48	26-2	0	29-5	0.48	27-4	0
					1-7	.31	5-12	.69	2-9	0.79	5-14	.93	4-11	0.58
					7-14	.58	12-18	1.24	9-15	.41	14-20	.69	11-18	0
					14-20	1.13	18-26	.93	15-21	.21	20-27	.76	18-25	.07
					20-27	.41			21-29	0				
Total seasonal:													11.79 inches	
1968	11-17	1.07	24-1	0.45	29-5	0.17	26-3	0	31-7	0.24	28-11	0.14	25-1	0
	17-24	1.75	1-8	.76	5-12	1.17	3-10	0.03	7-14	1.62	11-18	.45	1-9	0.72
			8-15	1.31	12-19	0	10-17	.38	14-23	.41	18-25	.27	9-16	1.03
			15-22	1.10	19-26	0	17-24	.14	23-28	0				
			22-29	.93			24-31	.38						
Total seasonal:													13.49 inches	
1969			29-7	0.07	27-4	0.03	24-1	0.89	30-6	0.31	27-3	0.55	24-1	0.62
			7-14	0	4-11	.24	1-8	.79	6-13	.69	3-10	.65	1-8	1.34
			14-21	.45	11-18	2.51	8-15	.34	13-20	.69	10-18	.69	8-15	1.03
			21-27	.03	18-24	1.99	15-23	1.10	20-27	.55	18-24	1.10		
							23-30	.34						
Total seasonal:													17.00 inches	
1970			12-20	0.21	27-3	0.48	27-4	0.03	25-1	0.03	29-5	0.27	26-3	0
			20-27	0	3-10	.41	4-11	1.58	1-8	.41	5-12	1.65		
					10-17	2.27	11-18	.07	8-15	0	12-19	.34		
					17-24	.14	18-25	.72	15-22	.38	19-26	.69		
					24-27	.03			22-29	.14				
Total seasonal:													9.85 inches	

TABLE B-1 (cont.)
CLIMATOLOGICAL SUMMARY
Park Range, Colorado

WEEKLY PRECIPITATION - INCHES

SODA CREEK STREAMGAGE, ELEVATION 8,300 FEET

Year	April		May		June		July		Aug.		Sept.		Oct.	
	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.
1971			29-6	0.17	26-3	1.96	1-8	0	29-5	0.03	2-10	1.37		
			6-13	.89	3-10	.31	8-15	0.03	5-11	.24	10-16	0		
			13-20	1.79	10-17	.17	15-22	.27	11-17	.10	16-23	.41		
			20-26	.10	17-23	.07	22-29	.03	17-26	0	23-1	.62		
					23-1	0			26-2	.41				
Total seasonal:												8.97 inches		
1972	9-12	0.79	3-10	1.44	31-6	0.17	27-5	0	1-9	0.69	29-5	0.69		
	12-19	.27	10-17	.79	6-14	.82	5-11	0.07	9-16	0	5-12	.82		
	19-26	.69	17-23	.14	14-20	.24	11-17	.34	16-22	.65				
	26-3	.10	23-31	0	20-27	.45	17-26	0	22-29	.17				
							26-1	.34						
Total seasonal:												9.67 inches		

TABLE B-2
CLIMATOLOGICAL SUMMARY
Park Range, Colorado

WEEKLY PRECIPITATION - INCHES

S-2 (SODA CREEK), ELEVATION 9,200 FEET^{1/}

Year	April		May		June		July		Aug.		Sept.		Oct.	
	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.
1967					18-1	1.48	27-5	0.41	26-2	0.14	21-5	0.79		
					1-7	.31	5-12	.82	2-9	.72	5-14	.69		
					7-14	.65	12-18	1.13	9-15	.45	14-20	.69		
					14-21	1.00	18-26	.79	15-21	.34				
					21-27	.38								
Total seasonal:												10.79 inches		
1968	11-17	1.17	24-1	0.41	29-5	0.14	26-3	0.03	31-9	0.52	28-12	0.86	25-1	0
	17-24	3.57	1-9	1.03	5-12	1.44	3-10	.07	9-14	1.31	12-18	.72	1-9	1.13
			9-15	1.31	12-19	0	10-17	.69	14-23	.76	18-25	.41		
			15-22	.82	19-26	0	17-24	.21	23-28	.03				
			22-29	.41			24-31	.38						
Total seasonal:												17.42 inches		

^{1/} On Buffalo Pass Road at Uppermost Switchback

TABLE B-3
CLIMATOLOGY SUMMARY
Park Range, Colorado

WEEKLY PRECIPITATION - INCHES

S-3 (FISH CREEK), ELEVATION 10,150 FEET^{1/}

Year	April		May		June		July		Aug.		Sept.		Oct.	
	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.
1967					18-1	2.27	27-5	0.55	26-2	0.10	21-5	0.24	27-4	0.24
					1-7	.34	5-12	.50	2-9	.89	5-14	2.34	4-11	.96
					7-14	.82	12-18	1.27	9-15	.21	14-20	.89	11-18	0
					14-21	1.37	18-26	.58	15-21	.45	20-27	.10	18-25	.10
					21-27	.52								
											Total seasonal:		13.69 inches	
1968			9-15	2.03	29-5	0.17	26-3	0.07	31-14	2.06	28-12	0.89	25-1	0
			15-22	1.37	5-12	1.82	3-10	.07	14-23	1.03	12-18	.82	1-9	1.48
			22-29	1.41	12-19	0	10-17	.38	23-28	.34	18-25	.41		
					19-26	0	17-24	.24						
							24-31	.48						
											Total seasonal:		15.07 inches	

^{1/} On Buffalo Pass Road at Divide between Fish and Soda Creek Watersheds.

TABLE B-4
CLIMATOLOGY SUMMARY
Park Range, Colorado

WEEKLY PRECIPITATION - INCHES

FISH CREEK STREAMGAGE, ELEVATION 9,800 FEET

Year	April		May		June		July		Aug.		Sept.		Oct.	
	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.
1967					18-1	2.10	27-5	0.48	26-2	0.10	29-5	0.65	27-4	0.07
					1-7	.27	5-12	.45	2-9	.89	5-14	2.03	4-11	.79
					7-14	.86	12-18	1.24	9-15	.34	14-20	.86	11-18	0
					14-21	1.44	18-26	.45	15-21	.27	20-27	.27	18-25	.10
					21-27	.72			21-29	0				
Total seasonal:													14.38 inches	
1968			9-15	1.51	29-5	0.21	26-3	0.03	31-9	0.65	28-12	0.89	25-1	0
			15-22	1.27	5-12	1.72	3-10	.10	9-14	1.48	12-18	.82	1-9	1.34
			22-29	1.34	12-19	0	10-17	.48	14-23	1.00	18-25	.38		
					19-26	0	17-24	.17	23-28	.24				
							24-31	.45						
Total seasonal:													14.08 inches	
1969			29-7	0.10	27-3	0.07	25-2	0.79	30-6	0.41	27-3	0.62	24-1	0.96
			7-14	.03	3-10	.69	2-8	.82	6-13	1.03	3-10	1.10	1-8	1.65
			14-20	.55	10-18	2.47	8-16	.45	13-20	1.27	10-18	.79	8-19	2.37
			20-27	0	18-25	2.99	16-23	1.27	20-27	.24	18-24	1.13		
							23-30	1.41						
Total seasonal:													23.21 inches	
1970					10-17	1.99	27-4	0.07	25-1	0.14	29-5	0.17	26-3	0.10
					17-24	.17	4-11	.58	1-8	.89	5-12	2.51		
					24-27	.03	11-18	.10	8-15	.03	12-19	.41		
							18-25	1.34	15-22	.52	19-26	.72		
										22-29	.10			
Total seasonal:													9.87 inches	

TABLE B-4 (cont.)

CLIMATOLOGICAL SUMMARY

Park Range, Colorado

WEEKLY PRECIPITATION - INCHES

FISH CREEK STREAMGAGE, ELEVATION 9,800 FEET

Year	April		May		June		July		Aug.		Sept.		Oct.	
	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.
1971			29-6	5.05	26-3	1.55	2-8	0	29-5	1.10	2-10	1.96		
			6-13	.27	3-10	.48	8-15	0.03	5-11	.10	10-16	0		
			13-20	1.89	10-17	.38	15-22	.62	11-19	.31	16-23	.58		
			20-26	.17	17-24	0	22-29	.07	19-26	.34				
					24-2	.10			26-2	.31				
Total seasonal:													16.31 inches	
1972	12-19	1.00	3-10	2.17	31-7	0.24	27-5	0	1-9	0.72	29-5	0.76		
	19-26	.45	10-17	.76	7-14	1.51	5-11	0.07	9-16	0	5-12	.93		
	26-3	.27	17-24	.17	14-21	.27	11-20	.31	16-22	.72	12-19	.62		
			24-31	0	21-27	.31	20-26	0	22-29	.24	19-27	.41		
							26-1	.45			27-4	1.10		
Total seasonal:													13.48 inches	

TABLE B-5
CLIMATOLOGICAL SUMMARY
Park Range, Colorado

WEEKLY PRECIPITATION - INCHES

WALTON CREEK STREAMGAGE, ELEVATION 9,100 FEET

Year	April		May		June		July		Aug.		Sept.		Oct.	
	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.
1967			17-31	1.20	31-6	0	27-5	0	26-2	0.07	29-5	0.72	27-4	0.24
					6-13	0.62	5-12	0.07	2-9	.58	5-14	1.17	4-11	.72
					13-20	1.51	12-18	.34	9-15	.45	14-20	.89	11-18	0
					20-27	.62	18-26	.34	15-21	.10	20-27	.24	18-25	.41
									21-29	.21				
Total seasonal:													10.50 inches	
1968			1-8	0.86	29-5	0.24	25-2	0	30-14	1.86	21-11	0.48	25-1	0.07
			8-14	.76	5-11	1.10	2-9	0.17	14-21	1.37	11-18	.72	1-9	1.31
			14-21	2.44	11-18	0	9-16	.41			18-25	.31	9-16	.93
			21-29	1.55	18-25	.07	16-23	.14						
							23-30	.69						
Total seasonal:													15.48 inches	
1969			30-6	0.17	28-4	0.21	25-2	0.34	30-7	0.21	27-3	1.17	24-1	0.62
			6-13	0	4-11	.07	2-8	.31	7-13	.48	3-10	.34	1-8	1.65
			13-21	.52	11-18	2.54	8-15	.93	13-20	.58	10-18	.48	8-15	1.51
			21-28	0	18-25	2.03	15-23	.76	20-27	.58	18-24	.86		
							23-30	1.10						
Total seasonal:													17.46 inches	
1970					10-17	2.20	27-4	0.10	25-1	0.34	29-5	0.03	26-2	0.03
					17-24	.21	4-11	1.31	1-8	.45	5-11	.86	2-9	2.06
					24-27	0	11-18	.10	8-15	.03	11-19	1.07		
							18-25	1.44	15-22	.34	19-26	.58		
									22-29	.34				
Total seasonal:													11.49 inches	

CLIMATOLOGICAL SUMMARY
Park Range, Colorado

WALTON CREEK STREAMGAGE, ELEVATION 9,100 FEET

Year	April		May		June		July		Aug.		Sept.		Oct.	
	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.
1971	22-27	0.65	6-13	0.79	3-10	0.72	1-8	0.03	29-5	0.10	2-10	1.89	1-8	0.38
	27-6	.27	13-19	1.65	10-17	.03	8-15	.07	5-11	0	10-16	0		
			19-26	.10	17-23	.07	15-22	.24	11-19	.14	16-23	.41		
			26-3	1.86	23-1	.31	22-29	.17	19-25	0	23-1	.41		
									25-2	.38				
												Total seasonal:	10.67	inches
1972	6-12	1.07	2-9	2.30	30-6	0.21	27-5	0	1-8	0.52	29-5	0.65		
	12-18	.31	9-16	1.31	6-13	.82	5-11	0.10	8-16	0	5-13	1.27		
	18-25	.07	16-23	.14	13-20	.52	11-25	.38	16-22	.96	13-19	.62		
	25-2	1.82	23-30	0	20-27	.31	25-1	.45	22-29	.21	19-26	.69		
											26-3	.69		
												Total seasonal:	15.42	inches

TABLE B-6
CLIMATOLOGICAL SUMMARY
Park Range, Colorado

WEEKLY PRECIPITATION - INCHES

W-2 (WALTON CREEK), ELEVATION 9,260 FEET^{1/}

Year	April		May		June		July		Aug.		Sept.		Oct.	
	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.	Intvl.	Amt.
1967			17-31	1.31	31-6	0	27-5	0.24	26-2	0.14	21-5	0.95	27-4	0.31
					6-13	0.76	5-12	.58	2-9	.60	5-14	1.20	4-11	.72
					13-20	1.75	12-18	.86	9-15	.62	14-20	.93	11-18	0
					20-27	1.10	18-26	.24	15-21	.17	20-27	.24	18-25	.34
											Total seasonal:		11.53 inches	
1968			22-29	1.20	29-5	0.17	25-2	0.03	30-14	1.75	21-11	0.69	25-1	0.07
					5-11	.89	2-9	.24	14-21	1.10	11-18	.72		
					11-18	0	9-16	.27			18-25	.31		
					18-25	0	16-23	.14						
							23-30	.58						
											Total seasonal:		8.16 inches	

^{1/} On north side of U.S. Highway 40; 1.0 mile west from Meadows Campground.

APPENDIX C

WATER BALANCE SIMULATION

05/22/73 16.44.22.
AVERAGE OF YEARS 1967 - 1971

05/22/73 16.44.22.

DUTH SODA CREEK

		CURRENT		INTERVAL		TOTALS		YEAR TO		DATE		DISCHARGE		(ROUTING)	
		SNOWPACK	RECHARGE	PRECIP	INPUT	EVAPOTRANS	GENERATED	PRECIP	INPUT	EVAPOTRANS	GEN	CHANGE IN	INTERVAL TOT	YEAR TO	DATE
		W. E.	REQ			FROM	RUNOFF				RUNOFF	RECHRG REQ	SIM	OBS	OBS
10	6	2.26	-2.10	2.68	.33	.1604	.10	2.68	.33	.1604	.10	.17	.04	.03	
	ALT 2	2.26	-2.22	2.68	.33	.1582	.10	2.68	.33	.1582	.10	.17	.04	.03	10
10	12	3.92	-2.06	1.91	.16	.1729	.04	4.59	.48	.3333	.14	.22	.06	.08	
	ALT 2	3.92	-2.17	1.91	.16	.1720	.04	4.59	.48	.3302	.14	.22	.06	.11	10 1
10	18	5.60	-2.01	1.97	.16	.1799	.06	6.56	.65	.5132	.20	.27	.07	.04	
	ALT 2	5.60	-2.12	1.97	.16	.1799	.06	6.56	.65	.5101	.19	.27	.07	.17	10 1
10	24	5.94	-2.04	.50	.03	.1947	.01	7.07	.68	.7079	.20	.24	.02	0.00	
	ALT 2	5.94	-2.15	.50	.03	.1944	.01	7.07	.68	.7044	.20	.24	.02	.20	10 2
10	30	6.38	-1.96	.83	.25	.1819	.12	7.90	.93	.8897	.32	.32	.08	0.00	
	ALT 2	6.38	-2.04	.83	.25	.1817	.09	7.90	.93	.8862	.30	.35	.06	.28	10 3
11	5	6.83	-1.95	.53	.03	.0806	.01	8.44	.96	.9703	.33	.33	.05	0.00	
	ALT 2	6.89	-2.04	.60	.03	.0808	.01	8.50	.96	.9670	.31	.36	.04	.32	11
11	11	7.92	-1.95	1.17	.01	.0768	0.00	9.61	.97	1.0471	.33	.33	.01	0.00	
	ALT 2	8.16	-2.04	1.34	.01	.0793	0.00	9.85	.97	1.0463	.31	.36	.01	.33	11 11
11	17	9.16	-1.97	1.32	0.00	.0843	0.00	10.92	.97	1.1314	.33	.31	.00	0.00	
	ALT 2	9.59	-2.05	1.51	0.00	.0867	0.00	11.36	.97	1.1329	.31	.34	.00	.34	11 17
11	23	10.66	-1.97	1.57	0.00	.0803	0.00	12.49	.97	1.2117	.33	.30	.00	0.00	
	ALT 2	11.32	-2.06	1.80	0.00	.0831	0.00	13.16	.97	1.2161	.31	.33	.00	.34	11 21
11	29	11.22	-1.98	.62	0.00	.0637	0.00	12.11	.97	1.2754	.33	.30	.00	0.00	
	ALT 2	11.98	-2.06	.72	0.00	.0657	0.00	12.88	.97	1.2818	.31	.33	.00	.34	11 26
12	5	12.20	-1.98	1.03	0.00	.0456	0.00	14.14	.97	1.3210	.33	.30	.00	0.00	
	ALT 2	13.11	-2.06	1.19	0.00	.0477	0.00	15.07	.97	1.3295	.31	.33	.00	.34	12
12	11	14.36	-1.98	2.22	0.00	.0551	0.00	16.36	.97	1.3761	.33	.30	.00	0.00	
	ALT 2	15.60	-2.06	2.55	0.00	.0575	0.00	17.61	.97	1.3870	.31	.33	.00	.35	12 12
12	17	15.00	-1.98	.67	0.00	.0395	0.00	17.03	.97	1.4156	.33	.30	.00	0.00	
	ALT 2	16.33	-2.06	.77	0.00	.0406	0.00	18.39	.97	1.4276	.31	.33	.00	.35	12 17
12	23	16.32	-1.98	1.36	0.00	.0483	0.00	18.40	.97	1.4639	.33	.30	.00	0.00	
	ALT 2	17.86	-2.06	1.57	0.00	.0505	0.00	19.96	.97	1.4781	.31	.33	.00	.35	12 23
12	29	18.73	-1.98	2.48	0.00	.0572	0.00	20.88	.97	1.5211	.33	.30	.00	0.00	
	ALT 2	20.63	-2.06	2.85	0.00	.0598	0.00	22.81	.97	1.5378	.31	.33	.00	.35	12 29
1	4	20.59	-1.98	1.91	0.00	.0599	0.00	22.79	.97	1.5809	.33	.30	.00	0.00	
	ALT 2	22.79	-2.06	2.20	0.00	.0629	0.00	25.01	.97	1.6007	.31	.33	.00	.35	1
1	10	21.92	-1.98	1.39	0.00	.0488	0.00	24.18	.97	1.6298	.33	.30	.00	0.00	
	ALT 2	24.32	-2.06	1.60	0.00	.0504	0.00	26.61	.97	1.6511	.31	.33	.00	.35	1 10
1	16	23.32	-1.98	1.45	0.00	.0553	0.00	25.63	.97	1.6851	.33	.30	.00	0.00	
	ALT 2	25.94	-2.06	1.67	0.00	.0578	0.00	26.27	.97	1.7090	.31	.33	.00	.36	1 16
1	22	25.49	-1.98	2.23	0.00	.0606	0.00	27.86	.97	1.7457	.33	.30	.00	0.00	
	ALT 2	28.44	-2.06	2.57	0.00	.0627	0.00	30.84	.97	1.7716	.31	.33	.00	.36	1 22
1	28	28.08	-1.98	2.68	0.00	.0666	0.00	30.54	.97	1.8123	.33	.30	.00	0.00	
	ALT 2	31.43	-2.06	3.08	0.00	.0692	0.00	33.92	.97	1.8408	.31	.33	.00	.36	1 28
2	3	29.80	-1.98	1.76	0.00	.0694	0.00	32.30	.97	1.8817	.33	.30	.00	0.00	
	ALT 2	33.40	-2.06	2.03	0.00	.0732	0.00	35.95	.97	1.9139	.31	.33	.00	.36	2
2	9	31.13	-1.98	1.39	0.00	.0635	0.00	33.69	.97	1.9452	.33	.30	.00	0.00	
	ALT 2	34.94	-2.06	1.59	0.00	.0660	0.00	37.54	.97	1.9800	.31	.33	.00	.36	2 9
2	15	32.58	-1.98	1.53	0.00	.0688	0.00	35.21	.97	2.0140	.33	.30	.00	0.00	
	ALT 2	36.62	-2.06	1.75	0.00	.0717	0.00	39.29	.97	2.0517	.31	.33	.00	.36	2 15
2	21	34.93	-1.98	2.43	0.00	.0819	0.00	37.65	.97	2.0959	.33	.30	.00	0.00	
	ALT 2	39.33	-2.06	2.80	0.00	.0856	0.00	42.09	.97	2.1373	.31	.33	.00	.37	2 21
2	27	36.14	-1.98	1.27	0.00	.0650	0.00	38.91	.97	2.1608	.33	.30	.00	0.00	
	ALT 2	40.73	-2.06	1.46	0.00	.0676	0.00	43.55	.97	2.2048	.31	.33	.00	.37	2 27
3	4	36.33	-1.98	.30	0.00	.0778	0.00	39.21	.97	2.2386	.33	.30	.00	0.00	
	ALT 2	40.96	-2.06	.34	0.00	.0790	0.00	43.89	.97	2.2838	.31	.33	.00	.37	3

ALTERNATIVE 2 - CLOUD SEEDING FROM 11/ 1 TO 3/31 INCREASES PRECIP BY 15 PERCENT

WATER BALANCE SIMULATION

05/22/73 16.44.22. 05/22/73 16.44.22.

AVERAGE OF YEARS 1967 - 1971

SOUTH SODA CREEK

		CURRENT		INTERVAL TOTALS				YEAR TO			DATE		DISCHARGE		(ROUTING)	
		SNOWPACK	RECHARGE	PRECIP	INPUT	EVAPOTRANS	GENERATED	PRECIP	INPUT	EVAPOTRANS	GEN	CHANGE IN	INTERVAL TOT	YEAR TO DATE		
		W. E.	REQ			FROM	RUNOFF				RUNOFF	RECHRG RQ	SIM	OBS	SIM	OBS
3 10		37.38	-1.98	1.15	0.00	.0961	0.00	40.36	.97	2.3347	.33	.30	.00	0.00	.37	.15
	ALT 2	42.18	-2.06	1.32	0.00	.0996	0.00	45.21	.97	2.3835	.31	.33	.00		.34	
3 16		38.39	-1.98	1.11	0.00	.1019	0.00	41.47	.97	2.4366	.33	.30	.00	0.00	.37	.15
	ALT 2	43.34	-2.06	1.27	0.00	.1054	0.00	46.49	.97	2.4889	.31	.33	.00		.35	
3 22		39.62	-1.98	1.35	0.00	.1144	0.00	42.82	.97	2.5510	.33	.30	.00	0.00	.37	.15
	ALT 2	44.78	-2.06	1.55	0.00	.1184	0.00	48.04	.97	2.6072	.31	.33	.00		.35	
3 28		40.31	-1.98	.82	0.00	.1250	0.00	43.63	.97	2.6760	.33	.30	.00	0.00	.38	.15
	ALT 2	45.59	-2.06	.94	0.00	.1275	0.00	48.98	.97	2.7347	.31	.33	.00		.35	
4 3		41.22	-1.98	1.09	0.00	.1907	0.00	44.73	.97	2.8667	.33	.30	.00	.01	.38	.16
	ALT 2	46.52	-2.06	1.12	0.00	.1914	0.00	50.10	.97	2.9261	.31	.33	.00		.35	
4 9		41.43	-1.97	.46	.01	.2430	.00	45.19	.98	3.1097	.34	.31	.00	.09	.38	.25
	ALT 2	46.74	-2.06	.46	0.00	.2430	0.00	50.56	.97	3.1692	.31	.33	.00		.35	
4 15		41.41	-1.85	.59	.31	.2993	.19	45.78	1.29	3.4081	.53	.43	.09	.25	.47	.50
	ALT 2	46.74	-1.94	.59	.28	.2983	.16	51.15	1.25	3.4675	.47	.45	.07		.43	
4 21		41.91	-1.77	1.05	.32	.2270	.24	46.83	1.61	3.5351	.76	.51	.20	.41	.67	.91
	ALT 2	47.25	-1.85	1.05	.32	.2270	.23	52.20	1.57	3.6945	.70	.55	.18		.61	
4 27		41.74	-1.71	.40	.34	.2211	.28	47.22	1.95	3.8562	1.05	.57	.27	.51	.94	1.41
	ALT 2	47.10	-1.80	.40	.32	.2211	.27	52.60	1.90	3.9157	.97	.60	.26		.87	
5 3		40.60	-1.55	.15	.87	.4265	.71	47.38	2.82	4.2827	1.75	.73	.48	.60	1.42	2.01
	ALT 2	45.98	-1.64	.15	.84	.4265	.68	52.75	2.74	4.3422	1.64	.76	.46		1.33	
5 9		38.94	-1.36	.26	1.40	.5205	1.21	47.44	4.22	4.8032	2.96	.92	.98	1.12	2.40	3.13
	ALT 2	44.36	-1.44	.26	1.37	.5205	1.18	53.01	4.11	4.8626	2.82	.95	.96		2.28	
5 15		37.17	-1.17	.42	1.73	.4750	1.54	48.06	5.94	5.2782	4.50	1.11	1.44	1.47	3.85	4.60
	ALT 2	42.62	-1.27	.42	1.68	.4750	1.51	53.43	5.79	5.3377	4.33	1.13	1.40		3.69	
5 21		34.77	-.86	.34	2.17	.5655	1.86	48.40	8.12	5.9437	6.35	1.42	1.61	2.11	5.46	6.71
	ALT 2	40.26	-.98	.34	2.14	.5676	1.84	53.77	7.92	5.9053	6.17	1.41	1.59		5.26	
5 27		31.14	-.50	.20	3.27	.5902	2.89	48.60	11.38	6.4339	9.24	1.78	2.57	3.49	8.02	10.20
	ALT 2	36.51	-.55	.20	3.38	.5957	2.94	53.97	11.30	6.5010	9.11	1.84	2.60		7.88	
6 2		26.97	-.20	.44	3.98	.6682	3.63	49.04	15.36	7.1022	12.88	2.08	3.37	3.74	11.39	13.94
	ALT 2	32.15	-.20	.44	4.15	.6796	3.76	54.42	15.45	7.1806	12.87	2.19	3.46		11.34	
6 8		20.30	-.08	.13	6.07	.8278	5.86	49.18	21.43	7.3299	18.73	2.20	5.46	4.31	16.85	18.26
	ALT 2	25.14	-.05	.13	6.39	.8471	6.15	54.55	21.84	8.0277	19.02	2.35	5.74		17.08	
6 14		15.95	-.07	.88	4.78	.5993	4.63	50.06	26.21	8.5292	23.36	2.21	4.96	3.45	21.81	21.71
	ALT 2	20.12	-.03	.88	5.38	.6321	5.25	55.43	27.22	8.6597	24.26	2.36	5.51		22.59	
6 20		11.17	-.13	.52	4.84	.6942	4.67	50.57	31.05	9.2233	28.02	2.15	4.55	4.70	26.36	26.41
	ALT 2	14.73	-.09	.52	5.37	.7398	5.23	55.95	32.59	9.3995	29.50	2.30	5.09		27.68	
6 26		7.53	-.27	.35	3.64	.6093	3.52	50.92	34.69	9.8326	31.54	2.01	3.84	4.74	30.20	31.15
	ALT 2	10.26	-.22	.35	4.43	.6440	4.31	56.30	37.02	10.0434	33.80	2.18	4.66		32.34	
7 2		4.46	-.55	.03	2.78	.6628	2.72	50.95	37.46	10.4954	34.26	1.72	2.93	3.25	33.13	34.40
	ALT 2	6.83	-.49	.03	3.09	.6813	3.04	56.32	40.11	10.7247	36.84	1.91	3.27		35.61	
7 8		1.92	-.72	.24	2.56	.6509	2.30	51.19	40.02	11.1463	36.55	1.56	2.45	1.78	35.58	36.18
	ALT 2	3.72	-.64	.24	3.04	.6767	2.83	56.57	43.15	11.4014	39.67	1.76	2.89		38.51	
7 14		.54	-1.02	.29	1.58	.6583	1.31	51.48	41.60	11.8046	37.87	1.26	1.67	.84	37.25	37.02
	ALT 2	1.46	-.90	.29	2.38	.6701	2.14	56.85	45.53	12.0715	41.81	1.49	2.42		40.92	
7 20		.07	-1.19	.44	.90	.5881	.50	51.92	42.50	12.3928	38.36	1.09	.80	.42	38.06	37.44
	ALT 2	.41	-1.04	.44	1.43	.5968	1.03	57.29	46.96	12.6683	42.84	1.36	1.37		42.30	
7 26		0.00	-1.54	.23	.30	.5885	.06	52.15	42.79	12.9813	38.42	.74	.31	.23	38.37	37.67
	ALT 2	.06	-1.38	.23	.57	.5961	.32	57.52	47.53	13.2644	43.16	1.02	.66		42.96	
8 1		0.00	-1.82	.33	.33	.5672	.04	52.48	43.13	13.5484	38.46	.46	.10	.12	38.47	37.79
	ALT 2	0.00	-1.66	.33	.39	.5827	.09	57.85	47.92	13.8471	43.25	.74	.25		43.21	
8 7		0.00	-2.02	.23	.23	.4367	0.00	52.71	43.36	13.9852	38.46	.26	.03	.07	38.50	37.86
	ALT 2	0.00	-1.88	.23	.23	.4543	0.00	58.09	48.16	14.3014	43.25	.51	.07		43.28	

ALTERNATIVE 2 - CLOUD SEEDING FROM 11/ 1 TO 3/31 INCREASES PRECIP BY 15 PERCENT

WATER BALANCE SIMULATION

05/22/73 16.44.22. 05/22/73 16.44.22.
AVERAGE OF YEARS 1967 - 1971

SOUTH SODA CREEK

	CURRENT		INTERVAL		TOTALS		YEAR TO			DATE	DISCHARGE		(ROUTING)	
	SNOWPACK	RECHARGE	PRECIP	INPUT	EVAPOTRANS	GENERATED	PRECIP	INPUT	EVAPOTRANS		CHANGE IN	INTERVAL	YEAR TO	DATE
	W. E.	REQ			FROM	RUNOFF				GEN	RECHRG RQ	TOT	SIM	ONS
8 13	0.00	-2.18	.28	.28	.4363	.00	52.99	43.64	14.4215	38.47	.10	.01	.05	38.51 37.91 8
ALT 2	0.00	-2.00	.28	.28	.4561	.00	59.37	48.43	14.7574	43.26	.33	.02		43.30
8 19	0.00	-2.37	.26	.26	.4433	.01	53.26	43.90	14.8648	38.48	-.10	.01	.04	38.52 37.94 8
ALT 2	0.00	-2.28	.26	.26	.4700	.01	58.63	48.70	15.2274	43.27	.11	.01		43.31
8 25	0.00	-2.53	.24	.24	.3748	.02	53.49	44.14	15.2396	38.50	-.25	.02	.02	38.54 37.97 8
ALT 2	0.00	-2.46	.24	.24	.3962	.02	58.86	48.93	15.6236	43.29	-.07	.02		43.33
8 31	0.00	-2.47	.37	.37	.3129	0.00	53.86	44.51	15.5524	38.50	-.20	.01	.01	38.55 37.98 8
ALT 2	0.00	-2.42	.37	.37	.3295	0.00	59.24	49.31	15.9531	43.29	-.02	.01		43.34
9 6	0.00	-2.43	.26	.26	.2115	.01	54.13	44.77	15.7639	38.51	-.15	.00	.01	38.55 37.99 9
ALT 2	0.00	-2.38	.26	.26	.2180	.01	59.50	49.56	16.1711	43.30	.01	.00		43.34
9 12	.01	-2.37	.34	.32	.2565	.01	54.46	45.09	16.0204	38.52	-.09	.01	.04	38.56 38.03 9
ALT 2	.01	-2.33	.34	.32	.2633	.01	59.84	49.89	16.4344	43.31	.06	.01		43.36
9 18	0.00	-2.42	.17	.18	.2302	0.00	54.64	45.28	16.2506	38.52	-.14	.01	.02	38.57 38.05 9
ALT 2	0.00	-2.38	.17	.18	.2352	0.00	60.01	50.07	16.6696	43.31	.01	.01		43.36
9 24	0.00	-2.33	.33	.32	.2314	.01	54.97	45.60	16.4820	38.53	-.05	.01	.04	38.58 38.09 9
ALT 2	0.00	-2.30	.33	.32	.2356	.01	60.34	50.40	16.9052	43.32	.10	.01		43.37
9 30	.00	-2.43	.13	.13	.2283	.00	55.10	45.73	16.7104	38.53	-.15	.00	.03	38.58 38.12 9
ALT 2	.00	-2.40	.13	.13	.2326	.00	60.47	50.52	17.1377	43.32	-.01	.00		43.38

ALTERNATIVE 2 - CLOUD SEEDING FROM 11/ 1 TO 3/31 INCREASES PRECIP BY 15 PERCENT

WATER BALANCE SIMULATION - YEARLY SUMMARY
SOUTH SODA CREEK

05/22/73 16.44.2

	PEAK WE	RECHARGE REQ 9/30	GENERATED RUNOFF	PRECIP	EVAPOTR	CHANGE IN RECH. REQ	DISCHARGE (ROUTING SIM OBS
1967	36.97	-2.11	35.78	53.26	17.68	-.20	35.82 36.27 196
ALT 2	42.01	-2.09	39.92	58.36	17.92	.52	39.97
CHANGE	5.04	.02	4.15	5.11	.24	.72	4.15
1968	38.27	-2.72	34.00	49.19	15.81	-.61	34.06 36.65 196
ALT 2	43.42	-2.68	38.64	54.37	16.33	-.60	38.70
CHANGE	5.15	.04	4.64	5.18	.52	.02	4.64
1969	39.15	-2.01	35.45	53.74	17.57	.72	35.49 35.00 196
ALT 2	44.20	-1.98	40.25	58.84	17.89	.71	40.29
CHANGE	5.05	.03	4.79	5.11	.32	-.01	4.79
1970	48.37	-2.55	42.95	59.00	16.59	-.55	43.01 42.07 197
ALT 2	53.58	-2.53	47.78	64.26	17.03	-.55	47.84
CHANGE	5.21	.02	4.83	5.27	.44	-.00	4.83
1971	50.53	-2.77	44.47	60.10	15.85	-.22	44.53 40.60 197
ALT 2	56.63	-2.73	50.01	66.27	16.46	-.20	50.07
CHANGE	6.10	.04	5.54	6.17	.61	.02	5.54

ALTERNATIVE 2 - CLOUD SEEDING FROM 11/ 1 TO 3/31 INCREASES PRECIP BY 15 PERCENT

TABLES: B-7 (S-2)
B-8 (S-3)
B-9 (Falsetop)

RECORDING RAIN GAGE SUMMARIES
FOR 1969-1972

CLIMATOLOGICAL SUMMARY
PARK RANGE, COLORADO

S-2 (SODA CREEK) ELEV-9,200 FT

YEAR 1969

DAY	DAILY PRECIPITATION - INCHES												DAY
	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	
1	M	M	M	M	.00	.00	.00	.00	.00	.00	M	M	1
2	M	M	M	M	.00	.00	.00	.00	.00	.48	M	M	2
3	M	M	M	.05	.00	.00	.11	.03	.00	.32	M	M	3
4	M	M	M	.05	.00	.00	.11	.05	.00	.42	M	M	4
5	M	M	M	.00	.07	.00	.62	.10	.00	.20	M	M	5
6	M	M	M	.32	.00	.00	.00	.01	.00	.02	M	M	6
7	M	M	M	.76	.07	.04	.00	.00	.00	.00	M	M	7
8	M	M	M	.22	.00	.14	.00	.00	.00	.00	M	M	8
9	M	M	M	.00	.00	.00	.00	.00	.17	.00	M	M	9
10	M	M	M	.00	.00	.00	.00	.00	.34	.37	M	M	10
11	M	M	M	.00	.00	.56	.00	.22	.00	.26	M	M	11
12	M	M	M	.19	.00	.47	.00	.60	.06	.25	M	M	12
13	M	M	M	.00	.00	.15	.00	.00	.25	.00	M	M	13
14	M	M	M	.09	.19	.00	.55	.00	.00	.27	M	M	14
15	M	M	M	.54	.17	.46	.00	.00	.17	.35	M	M	15
16	M	M	M	.00	.16	.56	.00	.00	.03	M	M	M	16
17	M	M	M	.00	.00	.52	.00	.04	.02	M	M	M	17
18	M	M	M	.00	.00	.00	.00	.79	.00	M	M	M	18
19	M	M	M	.01	.00	.01	.00	.00	.00	M	M	M	19
20	M	M	M	.00	.00	.17	1.12	.44	.12	M	M	M	20
21	M	M	M	.02	.00	.35	.00	.00	.50	M	M	M	21
22	M	M	M	.00	.00	.00	.00	.00	.48	M	M	M	22
23	M	M	M	.00	.00	.40	.00	.00	.00	M	M	M	23
24	M	M	M	.07	.00	1.32	.00	.00	.00	M	M	M	24
25	M	M	M	.72	.00	.40	.00	.00	.00	M	M	M	25
26	M	M	M	.33	.00	.18	.00	.00	.00	M	M	M	26
27	M	M	M	.12	.00	.00	.00	.04	.00	M	M	M	27
28	M	M	M	.00	.00	.00	.00	.12	.00	M	M	M	28
29	M		M	.00	.00	.00	.80	.49	.00	M	M	M	29
30	M		M	.00	.04	.00	.56	.04	.57	M	M	M	30
31	M		M		.00		.00	.00		M		M	31
TOT	0.00	0.00	0.00	3.49	.70	5.73	3.87	2.97	2.72	2.94	0.00	0.00	TOT

TOTAL PRECIPITATION = 22.42 INCHES

GAGE FIRST ESTABLISHED IN APRIL OF 1969.

M = MISSING DATA

CLIMATOLOGICAL SUMMARY
PARK RANGE, COLORADO

S-2 (SODA CREEK) ELEV-9,200 FT

YEAR 1970

DAY	DAILY PRECIPITATION - INCHES												DAY
	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	
1	M	M	M	M	.00	.00	.00	.00	.05	.00	M	M	1
2	M	M	M	M	.00	.00	.00	.06	.12	.00	M	M	2
3	M	M	M	M	.00	.00	.00	.00	.00	.00	M	M	3
4	M	M	M	M	.00	.00	.00	.12	.07	.00	M	M	4
5	M	M	M	M	.00	.00	.00	.00	.72	.00	M	M	5
6	M	M	M	M	.00	.00	.20	.18	.85	1.52	M	M	6
7	M	M	M	M	.00	.06	.12	.09	.17	.79	M	M	7
8	M	M	M	M	.25	.00	.00	.00	.00	.02	M	M	8
9	M	M	M	M	.35	.24	.82	.00	.01	.47	M	M	9
10	M	M	M	M	.30	.53	.10	.00	.00	M	M	M	10
11	M	M	M	M	.02	1.40	.00	.00	.00	M	M	M	11
12	M	M	M	M	.00	.56	.02	.00	.33	M	M	M	12
13	M	M	M	M	.00	.00	.00	.00	.00	M	M	M	13
14	M	M	M	M	.27	.00	.00	.00	.04	M	M	M	14
15	M	M	M	.02	.00	.00	.00	.00	.00	M	M	M	15
16	M	M	M	.00	.00	.00	.00	.00	.00	M	M	M	16
17	M	M	M	.20	.00	.00	.00	.30	.00	M	M	M	17
18	M	M	M	.77	.00	.00	.00	.00	.00	M	M	M	18
19	M	M	M	1.03	.00	.00	.28	.00	.00	M	M	M	19
20	M	M	M	.20	.00	.00	.00	.23	.00	M	M	M	20
21	M	M	M	.30	.00	.00	.07	.00	.45	M	M	M	21
22	M	M	M	.46	.00	.17	.19	.00	.07	M	M	M	22
23	M	M	M	.49	.00	.00	.30	.00	.00	M	M	M	23
24	M	M	M	.00	.00	.00	.00	.00	.05	M	M	M	24
25	M	M	M	.00	.00	.00	.00	.00	.12	M	M	M	25
26	M	M	M	.00	.00	.00	.07	.06	.00	M	M	M	26
27	M	M	M	.36	.00	.00	.00	.02	.00	M	M	M	27
28	M	M	M	.24	.12	.00	.00	.02	.00	M	M	M	28
29	M		M	.18	.32	.00	.00	.00	.00	M	M	M	29
30	M		M	.30	.04	.00	.00	.00	.00	M	M	M	30
31	M		M		.00		.00	.02		M		M	31
TOT	0.00	0.00	0.00	4.55	1.67	2.96	2.17	1.10	3.05	2.80	0.00	0.00	TOT

TOTAL PRECIPITATION = 18.30 INCHES

M = MISSING DATA

CLIMATOLOGICAL SUMMARY
PARK RANGE, COLORADO

S-2 (SODA CREEK) ELEV-9,200 FT

YEAR 1971

DAILY PRECIPITATION - INCHES

DAY	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	DAY
1	M	M	M	M	.00	.00	.00	.00	.00	.57	M	M	1
2	M	M	M	M	.00	.00	.01	.03	.04	.09	M	M	2
3	M	M	M	M	.00	.00	.00	.03	.32	.00	M	M	3
4	M	M	M	M	.00	.19	.00	.04	.58	.00	M	M	4
5	M	M	M	M	.00	.00	.00	.00	.04	.00	M	M	5
6	M	M	M	M	.00	.00	.00	.00	.00	.00	M	M	6
7	M	M	M	M	.08	.00	.02	.00	.67	.00	M	M	7
8	M	M	M	M	.37	.00	.03	.03	.00	M	M	M	8
9	M	M	M	M	.55	.22	.00	.21	.00	M	M	M	9
10	M	M	M	M	.04	.10	.00	.00	.00	M	M	M	10
11	M	M	M	M	.04	.00	.00	.03	.00	M	M	M	11
12	M	M	M	M	.02	.16	.00	.01	.00	M	M	M	12
13	M	M	M	M	.00	.00	.00	.04	.00	M	M	M	13
14	M	M	M	.00	.28	.00	.00	.00	.00	M	M	M	14
15	M	M	M	.14	.00	.05	.00	.00	.00	M	M	M	15
16	M	M	M	.00	.63	.00	.00	.00	.02	M	M	M	16
17	M	M	M	.00	.23	.00	.00	.00	.37	M	M	M	17
18	M	M	M	.05	.55	.00	.06	.00	.00	M	M	M	18
19	M	M	M	.60	.06	.00	.07	.00	.00	M	M	M	19
20	M	M	M	2.47	.00	.00	.00	.00	.00	M	M	M	20
21	M	M	M	.02	.00	.00	.18	.00	.21	M	M	M	21
22	M	M	M	.03	.05	.00	.03	.00	.00	M	M	M	22
23	M	M	M	.00	.07	.00	.00	.00	.00	M	M	M	23
24	M	M	M	.11	.02	.00	.00	.00	.00	M	M	M	24
25	M	M	M	.00	.00	.00	.00	.14	.00	M	M	M	25
26	M	M	M	.28	.00	.00	.00	.03	.00	M	M	M	26
27	M	M	M	.44	.00	.00	.00	.00	.00	M	M	M	27
28	M	M	M	.04	.18	.00	.00	.16	.00	M	M	M	28
29	M	M	M	.26	1.00	.00	.00	.02	.00	M	M	M	29
30	M	M	M	.00	.93	.00	.00	.17	.21	M	M	M	30
31	M	M	M		.09		.00	.00		M		M	31
TOT	0.00	0.00	0.00	4.44	5.19	.72	.40	.94	2.48	.66	0.00	0.00	TOT

TOTAL PRECIPITATION = 14.83 INCHES

M = MISSING DATA

CLIMATOLOGICAL SUMMARY
PARK RANGE, COLORADO

S-2 (SODA CREEK) ELEV-9,200 FT

YEAR 1972

DAILY PRECIPITATION - INCHES

DAY	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	DAY
1	M	M	M	.00	.00	.00	.00	.03	.26	.00	M	M	1
2	M	M	M	.33	.00	.00	.00	.10	.06	.00	M	M	2
3	M	M	M	.00	.00	.00	.00	.00	.06	.00	M	M	3
4	M	M	M	.00	.00	.04	.00	.00	.00	M	M	M	4
5	M	M	M	.00	.21	.14	.00	.09	.41	M	M	M	5
6	M	M	M	.14	.63	.00	.01	.00	.02	M	M	M	6
7	.00	M	M	.00	.40	.03	.07	.00	.22	M	M	M	7
8	.00	M	M	.00	.00	.70	.00	.00	.00	M	M	M	8
9	M	M	M	.00	.00	.06	.00	.00	.03	M	M	M	9
10	M	M	M	.00	.22	.00	.00	.00	.06	M	M	M	10
11	M	.00	M	.35	.55	.00	.03	.00	.08	M	M	M	11
12	M	M	.00	.35	.07	.00	.00	.00	.00	M	M	M	12
13	M	M	M	.10	.09	.00	.00	.00	.00	M	M	M	13
14	M	M	M	.16	.00	.00	.00	.00	.00	M	M	M	14
15	M	M	M	.03	.00	.00	.00	.00	.00	M	M	M	15
16	M	M	M	.00	.00	.00	.18	.07	.00	M	M	M	16
17	M	.00	M	.00	.00	.08	.00	.00	.00	M	M	M	17
18	M	M	M	.00	.00	.13	.00	.58	.01	M	M	M	18
19	M	M	M	.00	.12	.00	.15	.48	.48	M	M	M	19
20	M	M	M	.04	.00	.00	.00	.09	.04	M	M	M	20
21	M	M	M	.00	.00	.02	.00	.13	.00	M	M	M	21
22	M	M	M	.00	.00	.07	.00	.00	.00	M	M	M	22
23	M	M	M	.00	.00	.12	.00	.11	.00	M	M	M	23
24	M	M	.00	.00	.00	.00	.00	.00	.00	M	M	M	24
25	M	M	M	.37	.00	.00	.00	.00	.00	M	M	M	25
26	M	M	M	.34	.00	.03	.15	.00	.00	M	M	M	26
27	M	M	M	.05	.00	.00	.08	.00	.00	M	M	M	27
28	M	M	.02	.00	.00	.00	.00	.00	.63	M	M	M	28
29	M	M	.13	.00	.00	.00	.00	.22	.16	M	M	M	29
30	M		.31	.02	.00	.00	.00	.00	.00	M	M	M	30
31	M		.17		.00		.04	.05		M		M	31
TOT	0.00	0.00	.63	2.28	2.29	1.42	.71	1.95	2.52	0.00	0.00	0.00	TOT

TOTAL PRECIPITATION = 11.80 INCHES

M = MISSING DATA

CLIMATOLOGICAL SUMMARY
PARK RANGE, COLORADO

S-3 (FISH CR.) ELEV-10,150 FT

YEAR 1969

DAY	DAILY PRECIPITATION - INCHES												DAY
	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	
1	M	M	M	M	.00	.00	.00	.00	.00	.02	M	M	1
2	M	M	M	M	.00	.00	.00	.00	.00	.70	M	M	2
3	M	M	M	.05	.00	.00	.13	.03	.02	.33	M	M	3
4	M	M	M	.00	.00	.00	.14	.02	.00	.33	M	M	4
5	M	M	M	.00	.22	.00	.58	.08	.00	.23	M	M	5
6	M	M	M	.24	.02	.00	.00	.00	.00	.04	M	M	6
7	M	M	M	.89	.07	.00	.00	.00	.00	.00	M	M	7
8	M	M	M	.31	.00	.49	.00	.00	.00	.00	M	M	8
9	M	M	M	.01	.00	.00	.00	.00	.20	.00	M	M	9
10	M	M	M	.00	.00	.03	.00	.00	1.05	.68	M	M	10
11	M	M	M	.00	.00	.57	.00	.15	.00	.50	M	M	11
12	M	M	M	.19	.00	.29	.00	.71	.04	.27	M	M	12
13	M	M	M	.03	.00	.23	.00	.02	.25	.00	M	M	13
14	M	M	M	.08	.12	.02	.38	.00	.00	.29	M	M	14
15	M	M	M	.47	.17	.45	.00	.00	.60	.30	M	M	15
16	M	M	M	.00	.27	.69	.00	.00	.04	.30	M	M	16
17	M	M	M	.00	.02	.23	.00	.13	.00	.98	M	M	17
18	M	M	M	.00	.00	.00	.00	.37	.00	.58	M	M	18
19	M	M	M	.00	.00	.00	.00	.00	.00	.02	M	M	19
20	M	M	M	.00	.00	.25	1.31	.90	.07	M	M	M	20
21	M	M	M	.00	.00	.41	.00	.00	.65	M	M	M	21
22	M	M	M	.00	.00	.00	.00	.00	.48	M	M	M	22
23	M	M	M	.00	.00	.50	.00	.00	.00	M	M	M	23
24	M	M	M	.02	.00	1.21	.00	.02	.00	M	M	M	24
25	M	M	M	.80	.00	.66	.00	.00	.00	M	M	M	25
26	M	M	M	.32	.00	.36	.00	.00	.00	M	M	M	26
27	M	M	M	.12	.00	.00	.00	.00	.00	M	M	M	27
28	M	M	M	.01	.00	.00	.00	.08	.00	M	M	M	28
29	M	M	M	.00	.00	.00	.76	.44	.00	M	M	M	29
30	M	M	M	.00	.07	.00	.72	.00	.80	M	M	M	30
31	M	M	M		.00		.00	.00		M		M	31
TOT	0.00	0.00	0.00	3.53	.96	6.49	4.02	2.95	4.20	5.57	0.00	0.00	TOT

TOTAL PRECIPITATION = 27.72 INCHES

GAGE FIRST ESTABLISHED IN APRIL OF 1969.

M = MISSING DATA

CLIMATOLOGICAL SUMMARY
PARK RANGE, COLORADO

S-3 (FISH CR.) ELEV-10,150 FT

YEAR 1970

DAY	DAILY PRECIPITATION - INCHES												DAY
	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	
1	M	M	M	M	.11	.00	.00	.00	.04	.00	M	M	1
2	M	M	M	M	.00	.00	.00	.07	.07	.00	M	M	2
3	M	M	M	M	.00	.00	.00	.00	.00	.00	M	M	3
4	M	M	M	M	.00	.00	.00	.16	.05	.00	M	M	4
5	M	M	M	M	.00	.00	.00	.02	.79	.00	M	M	5
6	M	M	M	M	.00	.00	.27	.29	1.24	1.64	M	M	6
7	M	M	M	M	.00	.13	.17	.20	.61	.58	M	M	7
8	M	M	M	M	.37	.00	.00	.01	.00	.00	M	M	8
9	M	M	M	M	.53	.53	.27	.00	.00	.20	M	M	9
10	M	M	M	M	.20	.59	.08	.00	.00	M	M	M	10
11	M	M	M	M	.00	1.44	.01	.00	.00	M	M	M	11
12	M	M	M	M	.00	.47	.02	.00	.33	M	M	M	12
13	M	M	M	M	.02	.00	.00	.00	.02	M	M	M	13
14	M	M	M	M	.46	.00	.00	.00	.03	M	M	M	14
15	M	M	M	.07	.00	.00	.00	.00	.00	M	M	M	15
16	M	M	M	.00	.00	.00	.00	.00	.00	M	M	M	16
17	M	M	M	.19	.00	.00	.00	.24	.00	M	M	M	17
18	M	M	M	.75	.00	.00	.00	.00	.00	M	M	M	18
19	M	M	M	1.05	.00	.00	.45	.05	.00	M	M	M	19
20	M	M	M	.18	.00	.02	.03	.23	.00	M	M	M	20
21	M	M	M	.35	.00	.00	.14	.03	.55	M	M	M	21
22	M	M	M	.61	.00	.12	.28	.00	.15	M	M	M	22
23	M	M	M	.67	.03	.00	.37	.01	.00	M	M	M	23
24	M	M	M	.00	.00	.00	.00	.00	.09	M	M	M	24
25	M	M	M	.00	.00	.00	.00	.00	.14	M	M	M	25
26	M	M	M	.00	.00	.00	.17	.10	.00	M	M	M	26
27	M	M	M	.38	.00	.00	.00	.00	.00	M	M	M	27
28	M	M	M	.27	.11	.00	.00	.03	.00	M	M	M	28
29	M		M	.19	.35	.03	.00	.00	.00	M	M	M	29
30	M		M	.33	.04	.00	.00	.00	.00	M	M	M	30
31	M		M		.02		.00	.00		M		M	31
TOT	0.00	0.00	0.00	5.04	2.24	3.33	2.26	1.44	4.11	2.42	0.00	0.00	TOT

TOTAL PRECIPITATION = 20.84 INCHES

M = MISSING DATA

CLIMATOLOGICAL SUMMARY
PARK RANGE, COLORADO

S-3 (FISH CR.) ELEV-10,150 FT

YEAR 1971

DAILY PRECIPITATION - INCHES													
DAY	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	DAY
1	M	M	M	M	.00	.00	.00	.00	.00	M	M	M	1
2	M	M	M	M	.00	.00	.00	.03	.06	M	M	M	2
3	M	M	M	M	.00	.00	.00	.20	.33	M	M	M	3
4	M	M	M	M	.00	.21	.00	.77	.68	M	M	M	4
5	M	M	M	M	.08	.00	.00	.00	.00	M	M	M	5
6	M	M	M	M	.00	.00	.00	.00	.00	M	M	M	6
7	M	M	M	M	.08	.00	.03	.00	.87	M	M	M	7
8	M	M	M	M	.43	.00	.05	.00	.00	M	M	M	8
9	M	M	M	M	.49	.20	.02	.07	.00	M	M	M	9
10	M	M	M	M	.07	.10	.00	.00	.00	M	M	M	10
11	M	M	M	M	.00	.00	.00	.07	.00	M	M	M	11
12	M	M	M	M	.00	.14	.00	.07	.00	M	M	M	12
13	M	M	M	M	.00	.00	.00	.06	.00	M	M	M	13
14	M	M	M	.00	.36	.00	.00	.00	.00	M	M	M	14
15	M	M	M	.19	.05	.08	.00	.00	.00	M	M	M	15
16	M	M	M	.00	.66	.00	.00	.00	.04	M	M	M	16
17	M	M	M	.00	.21	.00	.00	.00	.86	M	M	M	17
18	M	M	M	.03	.68	.00	.06	.00	.00	M	M	M	18
19	M	M	M	.56	.12	.00	.28	.00	.00	M	M	M	19
20	M	M	M	2.25	.00	.00	.00	.03	.00	M	M	M	20
21	M	M	M	.00	.00	.00	.14	.00	.23	M	M	M	21
22	M	M	M	.27	.10	.03	.00	.04	.00	M	M	M	22
23	M	M	M	.01	.05	.00	.04	.04	M	M	M	M	23
24	M	M	M	.15	.00	.00	.03	.03	M	M	M	M	24
25	M	M	M	.00	.00	.00	.00	.00	M	M	M	M	25
26	M	M	M	.60	.00	.00	.00	.03	M	M	M	M	26
27	M	M	M	.75	.00	.00	.00	.15	M	M	M	M	27
28	M	.00	M	.02	.14	.00	.00	.13	M	M	M	M	28
29	M		M	.29	.74	.03	.00	.00	M	M	M	M	29
30	M		M	.00	.86	.00	.00	.17	M	M	M	M	30
31	M		M		.16		.00	.00		M		M	31
TOT	0.00	0.00	0.00	5.12	5.28	.79	.65	1.89	3.07	0.00	0.00	0.00	TOT

TOTAL PRECIPITATION = 16.80 INCHES

M = MISSING DATA

CLIMATOLOGICAL SUMMARY
PARK RANGE, COLORADO

S-3 (FISH CR.) ELEV-10,150 FT

YEAR 1972

DAY	DAILY PRECIPITATION - INCHES												DAY
	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	
1	M	M	M	.00	.00	.10	.00	.02	.32	.00	M	M	1
2	M	M	M	.43	.00	.00	.00	.56	.06	.00	M	M	2
3	M	M	M	.00	.00	.00	.00	.00	.11	.00	M	M	3
4	M	M	M	.00	.00	.00	.00	.00	.00	M	M	M	4
5	M	M	M	.00	.27	.07	.00	.11	.48	M	M	M	5
6	M	M	M	.30	.94	.07	.01	.00	.06	M	M	M	6
7	M	M	M	.00	.47	.00	.02	.00	.19	M	M	M	7
8	M	M	M	.00	.00	1.55	.00	.00	.00	M	M	M	8
9	M	M	M	.00	.00	.07	.00	.00	.05	M	M	M	9
10	M	M	M	.00	.33	.00	.00	.00	.04	M	M	M	10
11	M	M	M	.74	.43	.00	.07	.00	.11	M	M	M	11
12	M	M	M	.38	.12	.00	.00	.00	.00	M	M	M	12
13	M	M	M	.13	.12	.00	.00	.00	.00	M	M	M	13
14	M	M	M	.24	.00	.00	.00	.00	.00	M	M	M	14
15	.00	M	M	.10	.00	.00	.00	.00	.00	M	M	M	15
16	.00	M	M	.00	.00	.00	.07	.05	.00	M	M	M	16
17	.00	M	M	.00	.00	.09	.00	.00	.00	M	M	M	17
18	.00	M	M	.00	.00	.18	.00	.29	.04	M	M	M	18
19	.00	M	M	.00	.17	.00	.16	.40	.86	M	M	M	19
20	M	M	M	.00	.00	.00	.04	.15	.12	M	M	M	20
21	M	M	M	.03	.00	.00	.00	.03	.00	M	M	M	21
22	M	M	M	.00	.00	.11	.00	.00	.00	M	M	M	22
23	M	M	M	.00	.00	.13	.00	.11	.00	M	M	M	23
24	.00	M	.00	.00	.00	.00	.00	.00	.00	M	M	M	24
25	M	M	M	.31	.00	.00	.00	.00	.00	M	M	M	25
26	M	M	M	.35	.00	.00	.25	.00	.00	M	M	M	26
27	M	M	M	.09	.00	.00	.13	.00	.00	M	M	M	27
28	M	M	.03	.00	.00	.00	.00	.00	.88	M	M	M	28
29	M	M	.16	.04	.00	.00	.00	.10	.19	M	M	M	29
30	M		.35	.05	.00	.00	.00	.00	.00	M	M	M	30
31	M		.20		.00		.02	.02		M		M	31
TOT	0.00	0.00	.74	3.19	2.85	2.37	.78	1.84	3.51	0.00	0.00	0.00	TOT

TOTAL PRECIPITATION = 15.28 INCHES

M = MISSING DATA

CLIMATOLOGICAL SUMMARY
PARK RANGE, COLORADO WALTON CREEK

FALSETOP ELEV-9,400 FT

YEAR 1969

DAILY PRECIPITATION - INCHES

DAY	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	DAY
1	M	M	M	M	.00	.00	.00	.00	.00	.00	M	M	1
2	M	M	M	M	.00	.00	.00	.00	.00	.89	M	M	2
3	M	M	M	.05	.00	.00	.00	.00	.00	.32	M	M	3
4	M	M	M	.13	.14	.00	.00	.04	.02	.37	M	M	4
5	M	M	M	.00	.00	.00	.14	.13	.00	.16	M	M	5
6	M	M	M	.37	.00	.00	.00	.00	.00	.00	M	M	6
7	M	M	M	.59	.00	.00	.00	.00	.00	.00	M	M	7
8	M	M	M	.06	.00	.00	.00	.00	.00	.00	M	M	8
9	M	M	M	.00	.00	.00	.00	.00	.23	.00	M	M	9
10	M	M	M	.00	.00	.00	.00	.00	.22	.29	M	M	10
11	M	M	M	.00	.00	.35	.00	.08	.00	.21	M	M	11
12	M	M	M	.23	.00	.11	.00	.30	.05	.19	M	M	12
13	M	M	M	.00	.00	.08	.00	.00	.05	.00	M	M	13
14	M	M	M	.14	.00	.00	.59	.00	.00	.32	M	M	14
15	M	M	M	.20	.26	.68	.00	.00	.11	.67	M	M	15
16	M	M	M	.00	.26	.52	.00	.00	.00	M	M	M	16
17	M	M	M	.00	.00	.42	.00	.07	.04	M	M	M	17
18	M	M	M	.00	.00	.02	.00	.86	.00	M	M	M	18
19	M	M	M	.00	.00	.00	.00	.00	.00	M	M	M	19
20	M	M	M	.00	.00	.00	.74	.59	.00	M	M	M	20
21	M	M	M	.00	.00	.13	.05	.00	.64	M	M	M	21
22	M	M	M	.00	.00	.00	.00	.00	.26	M	M	M	22
23	M	M	M	.00	.00	.50	.00	.00	.00	M	M	M	23
24	M	M	M	.10	.00	.92	.00	.00	.00	M	M	M	24
25	M	M	M	.67	.00	.20	.00	.00	.00	M	M	M	25
26	M	M	M	.65	.00	.17	.00	.00	.00	M	M	M	26
27	M	M	M	.26	.00	.03	.00	.00	.00	M	M	M	27
28	M	M	M	.00	.00	.00	.00	.22	.00	M	M	M	28
29	M	M	M	.00	.00	.00	.72	.55	.00	M	M	M	29
30	M	M	M	.00	.14	.00	.35	.00	.51	M	M	M	30
31	M	M	M		.07		.00	.00		M		M	31
TOT	0.00	0.00	0.00	3.45	.87	4.13	2.59	2.84	2.13	3.42	0.00	0.00	TOT

TOTAL PRECIPITATION = 19.43 INCHES

GAGE FIRST ESTABLISHED IN APRIL OF 1969.

M = MISSING DATA

CLIMATOLOGICAL SUMMARY
PARK RANGE, COLORADO WALTON CREEK

		FALSETOP		ELEV-9,400 FT		DAILY PRECIPITATION - INCHES						YEAR 1970		
		JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	
DAY														DAY
1	M	M	M	M	.01	.00	.00	.00	.02	.00	M	M		1
2	M	M	M	M	.01	.00	.00	.00	.05	.00	M	M		2
3	M	M	M	M	.02	.00	.00	.00	.00	.00	M	M		3
4	M	M	M	M	.02	.00	.00	.06	.05	.00	M	M		4
5	M	M	M	M	.00	.00	.06	.00	.45	.00	M	M		5
6	M	M	M	M	.00	.03	.21	.02	.45	1.19	M	M		6
7	M	M	M	M	.00	.07	.00	.26	.00	.98	M	M		7
8	M	M	M	M	.14	.03	.00	.02	.00	.00	M	M		8
9	M	M	M	M	.53	.15	.30	.00	.00	.04	M	M		9
10	M	M	M	M	.10	.44	.39	.00	.00	M	M	M		10
11	M	M	M	M	.02	1.30	.00	.00	.00	M	M	M		11
12	M	M	M	M	.00	.98	.00	.00	.12	M	M	M		12
13	M	M	M	M	.00	.00	.00	.00	.27	M	M	M		13
14	M	M	M	M	.40	.00	.00	.00	.08	M	M	M		14
15	M	M	M	.10	.01	.00	.00	.00	.00	M	M	M		15
16	M	M	M	.00	.00	.00	.00	.00	.00	M	M	M		16
17	M	M	M	.26	.00	.00	.00	.04	.00	M	M	M		17
18	M	M	M	1.03	.00	.11	.00	.00	.00	M	M	M		18
19	M	M	M	1.49	.00	.00	.06	.00	.00	M	M	M		19
20	M	M	M	.25	.00	.00	.10	.09	.00	M	M	M		20
21	M	M	M	.48	.00	.00	.57	.28	.33	M	M	M		21
22	M	M	M	.76	.00	.06	.92	.00	.04	M	M	M		22
23	M	M	M	.67	.03	.00	.00	.00	.00	M	M	M		23
24	M	M	M	.00	.00	.00	.00	.00	.10	M	M	M		24
25	M	M	M	.00	.00	.00	.00	.00	.08	M	M	M		25
26	M	M	M	.00	.00	.00	.19	.11	.00	M	M	M		26
27	M	M	M	.11	.00	.00	.02	.12	.00	M	M	M		27
28	M	M	M	.09	.02	.00	.10	.03	.00	M	M	M		28
29	M		M	.05	.17	.00	.11	.01	.00	M	M	M		29
30	M		M	.25	.00	.00	.06	.00	.00	M	M	M		30
31	M		M		.05		.00	.10		.00		M		31
TOT	0.00	0.00	0.00	5.54	1.53	3.17	3.09	1.14	2.04	2.21	0.00	0.00	TOT	

TOTAL PRECIPITATION = 18.72 INCHES

M = MISSING DATA

CLIMATOLOGICAL SUMMARY
PARK RANGE, COLORADO WALTON CREEK

FALSETOP ELEV-9,400 FT

YEAR 1971

DAY	DAILY PRECIPITATION - INCHES												DAY
	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	
1	M	M	M	M	.00	.01	.00	.00	.00	.41	M	M	1
2	M	M	M	M	.00	.00	.00	.03	.00	.10	M	M	2
3	.00	M	M	M	.00	.00	.00	.04	.42	.00	M	M	3
4	M	M	M	M	.00	.20	.00	.07	.57	.00	M	M	4
5	M	M	M	M	.00	.00	.00	.00	.00	.00	M	M	5
6	M	M	M	M	.00	.05	.00	.00	.04	.00	M	M	6
7	M	M	M	M	.06	.00	.00	.00	.60	.00	M	M	7
8	M	M	M	M	.10	.00	.07	.00	.00	M	M	M	8
9	M	M	M	M	.66	.18	.07	.04	.00	M	M	M	9
10	M	M	M	M	.12	.00	.00	.00	.00	M	M	M	10
11	M	M	M	M	.00	.00	.00	.11	.00	M	M	M	11
12	M	M	M	M	.00	.04	.00	.02	.00	M	M	M	12
13	M	M	M	.00	.00	.00	.00	.14	.00	M	M	M	13
14	M	M	M	.00	.08	.00	.00	.00	.00	M	M	M	14
15	M	M	M	.08	.04	.03	.00	.00	.00	M	M	M	15
16	M	M	M	.00	.70	.00	.00	.00	.02	M	M	M	16
17	M	M	M	.00	.30	.00	.00	.13	.51	M	M	M	17
18	M	M	M	.05	.26	.03	.00	.00	.64	M	M	M	18
19	M	M	M	.66	.05	.00	.21	.00	.00	M	M	M	19
20	M	M	M	3.40	.00	.00	.00	.00	.00	M	M	M	20
21	M	M	M	.04	.00	.00	.58	.00	.15	M	M	M	21
22	M	M	M	.00	.05	.00	.00	.00	.00	M	M	M	22
23	M	M	M	.00	.26	.00	.00	.00	.00	M	M	M	23
24	M	M	M	.00	.00	.00	.00	.00	.00	M	M	M	24
25	M	M	M	.00	.03	.00	.00	.07	.00	M	M	M	25
26	M	M	M	.22	.00	.00	.00	.03	.00	M	M	M	26
27	M	M	M	.52	.00	.00	.00	.00	.00	M	M	M	27
28	M	M	M	.01	.16	.00	.00	.32	.00	M	M	M	28
29	M		M	.25	.84	.09	.00	.00	.00	M	M	M	29
30	M		M	.00	.54	.00	.00	.03	.68	M	M	M	30
31	.00		M		.09		.00	.00		M		M	31
TOT	0.00	0.00	0.00	5.23	4.34	.63	.93	1.03	2.43	.51	0.00	0.00	TOT

TOTAL PRECIPITATION = 15.10 INCHES

M = MISSING DATA

CLIMATOLOGICAL SUMMARY
PARK RANGE, COLORADO WALTON CREEK

		FALSETOP		ELEV-9,400 FT		DAILY PRECIPITATION - INCHES						YEAR 1972	
DAY	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	DAY
1	M	M	M	.00	.00	.00	.00	.00	.17	.00	M	M	1
2	M	M	M	.42	.00	.02	.00	.59	.12	.00	M	M	2
3	M	M	M	.00	.00	.00	.00	.00	.07	M	M	M	3
4	M	M	M	.00	.00	.02	.00	.00	.00	M	M	M	4
5	M	M	M	.00	.33	.07	.00	.03	.15	M	M	M	5
6	M	M	M	.46	.88	.00	.04	.00	.62	M	M	M	6
7	M	M	M	.00	.85	.07	.04	.00	.11	M	M	M	7
8	M	M	M	.00	.00	1.09	.00	.00	.00	M	M	M	8
9	M	M	M	.00	.00	.00	.00	.00	.00	M	M	M	9
10	M	M	M	.00	.43	.00	.15	.00	.10	M	M	M	10
11	M	M	M	.29	.51	.00	.07	.00	.00	M	M	M	11
12	M	M	M	.35	.06	.00	.00	.00	.00	M	M	M	12
13	M	M	M	.11	.21	.04	.00	.00	.00	M	M	M	13
14	M	M	M	.35	.03	.00	.00	.00	.00	M	M	M	14
15	M	M	M	.06	.00	.00	.00	.00	.00	M	M	M	15
16	M	M	M	.00	.00	.00	.00	.15	.00	M	M	M	16
17	M	M	M	.00	.00	.09	.00	.00	.00	M	M	M	17
18	M	M	M	.00	.00	.25	.00	.26	.00	M	M	M	18
19	M	M	M	.00	.10	.00	.20	.46	.99	M	M	M	19
20	M	M	M	.00	.00	.03	.14	.03	.07	M	M	M	20
21	M	M	M	.09	.00	.08	.00	.00	.00	M	M	M	21
22	M	M	M	.00	.00	.08	.00	.00	.00	M	M	M	22
23	M	M	M	.00	.00	.15	.00	.03	.00	M	M	M	23
24	M	M	M	.00	.00	.00	.03	.00	.00	M	M	M	24
25	M	M	M	.62	.00	.00	.00	.11	.00	M	M	M	25
26	M	M	M	1.14	.00	.00	.13	.00	.00	M	M	M	26
27	M	M	.00	.10	.00	.00	.15	.00	.00	M	M	M	27
28	M	M	.05	.00	.00	.00	.00	.00	.43	M	M	M	28
29	M	M	.16	.00	.00	.00	.00	.12	.23	M	M	M	29
30	M		.27	.00	.00	.00	.00	.03	.00	M	M	M	30
31	M		.13		.00		.00	.00		M		.00	31
TOT	0.00	0.00	.61	3.99	3.40	1.99	1.00	1.81	3.06	0.00	0.00	0.00	TOT

TOTAL PRECIPITATION = 15.86 INCHES

M = MISSING DATA